DISCOVERY

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The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

Science and the Citizen

BEFORE the last war, and for some time following it, scientists were content to watch with pride the steadily growing extent to which their work was changing the face of civilization—mainly for the better.

The Great Depression and the obvious wastage and misuse of science which accompanied it came as a rude shock which produced, in all except a few of the more original thinkers, a sense of frustration and perplexity.

All the more confusing was the fact that the frustration of science became most patent, at just about the same time as became apparent that in the Soviet Union science was taking its proper place as an integral part of the structure of the community. It was evident that that community had been organized in such a way that no barriers were presented to the fullest utilization of science for the raising of the material and intellectual standards of its people.

It is not surprising then that the first studies to appear in England of the relations between science and the community should have been the work of the scientific representatives of the U.S.S.R. They were presented by the Russian delegation at the International Congress of the History of Science and Technology held in London in 1931. It is recorded that the paper read by Professor Hessen on the work of Newton was received with an astonished silence, so startling were the ideas contained in it. The ideas did not remain startling for long. Hessen's work was eagerly seized upon and followed up in this country by a large number of writers.

Out of their work has grown a new study—that of the social relations of science. This means the study of the ways in which scientific progress affects the structure of civilization and the course of history, and, contrariwise, the way in which the development of history tends to encourage certain lines of investigation, and to discourage others. A very crude example is that of the invention of the counter to the magnetic mine, which was an urgent need, evoking the solution in a matter of days. In fact it is becoming clear that the influence of social needs on the course of even the most abstruse research is by no means negligible.

But the importance of the social relations of science is not confined to this comparatively academic study. The nations of the world are engaged in a desperate struggle to exterminate each other, and have made use of every possible application of scientific knowledge. There is talk—and in many ways premature—of reconstruction after the war.

How is science going to be used when that time comes? It can either be made an integral part of the life of the community, keyed into the social structure so that the benefits it can bring may be distributed to all: or there will be an attempt to bring back the conditions which existed before this war, in which case science will again be increasingly frustrated and denied as the road to social retrogression is pursued.

The two possibilities are in striking contrast. The Beveridge Report has become the symbol of social security. The money needed to operate it will be readily available if our scientific and productive resources are fully utilized. If, on the other hand, those resources remain in the hands of a few we may look forward to a future ever more full of want, restriction and war.

The subject of the social relations of science is thus an urgent social and political problem. The choice of the future depends in the last resort on the attitude of the mass of the voters. If there is a clear understanding of the choice and its consequences there can be little doubt which road will be taken.

Scientists therefore find themselves in the position of having to advertise to the public what they have to give. This means that popular science is no longer a medium for rousing a transitory interest—an intellectual thrill or a whiff of mystery—it is a medium for a definite social message.

Our scientists moreover, ought not to deceive themselves that this message will be delivered without encountering opposition. Such a message clashes with far too many organizations which have a large stake in the existing system. Opposition will arise at all levels from the mere cranks

learned in a bogus science, down to the much more sinister examples of those who may attempt to use that bogus science to provide a pseudo-scientific justification for an equally bogus political system. In between these two levels we shall encounter those concerned to defend their interests against scientific progress, either because it would render those interests obsolete, or because acceptance of new methods and ideas would involve too great a capital expenditure of either machine or mental equipment.

To-day the scientist is in search of allies among the general public. From the very nature of his work and training, and his whole mental outlook, he is a friend of progress and material betterment for the whole community. That community cannot dispense with him in war. It will be cutting its own throat if it tries to dispense with him in the post-war period.

To gain those allies he must take steps to inform the public of the implications of his work, and of its possibilities for the man in the street. That will in no sense lead to a degradation of his work, and concentration on mere applications. Every scientist knows that an enlightened and successful programme of applied research must use, or even create, the fundamental scientific knowledge which lies behind the application. This is one of the points that should be brought out by popular science: that science is a unity, and that sterility is the reward of a rigid separation of pure and applied science.

This is the situation that evoked the Conference of the British Association for the Advancement of Science which was held on March 20 and 21 under the title of "Science and the Citizen". It is the same situation which evoked the re-publication of *Discovery*.

Radio Plumbers

"We are only the plumbers," said Sir Robert Watson-Watt at the British Association's discussion on Radio and the Cinema, by which he meant that the engineers and scientists who have made radio possible are excluded from the administration and the formation of policy that control its use.

But it may not be long before there is an intimate connection between plumbing and radio, for a technique has been evolved for sending radio waves through hollow metal pipes called "wave guides". To the layman it may seem obvious that radio waves can be transmitted down pipes, just as sound waves can be sent down speaking tubes. However, the analogy is not quite fair, because sound waves are longitudinal, i.e. they are oscillation of air parallel to the direction of propagation of the waves. This means that the width of the tube does not matter, and if the length of the tube is shorter than the wavelength of the sound, it only means that the beginning of the wave arrives at the far end before the last part has been transmitted.

Radio waves, on the other hand, are *transverse* waves, i.e. the alternating electric and magnetic variations in which they consist are at right-angles to the direction of propagation, so that in the radio "wave guide" the wavelength has to fit into the diameter of the tube. Actually, the disposition of the electric and magnetic fields in the waves is not the same for waves in tubes as in the open, but it is still true that the longest wavelength which can be transmitted down a pipe is of about the same length as the diameter of the pipe.

It does not sound particularly impressive to say that the wavelength must be less than, say, 10 centimetres, but when it is realized that this involves alternations at frequencies of 3,000,000,000 times per second it becomes clear why it is only of recent years that the technique of generating suitable radiation has reached the practical stage.

These waves in pipes are genuine radio waves unlike the the high-frequency currents transmitted over wire circuits in carrier current telephony.

In the wave-guide method the waves are radiated from a small aerial inserted at one end of the pipe, and are picked up by another aerial at the receiving end. Alternatively, the pipe may end in a horn which will radiate the waves into the open, so that they may be received at any point in front of the horn instead of being piped to a single point only.

From another point of view the wave-guide method appears as the climax of a slow trend in line telephony and telegraphy.

The demand for communication channels was, almost from the start, so great, that the number of pairs of wires needed in a trunk cable was very large, and the cable cost thus formed a very large part of the expense of the system. It was soon found possible to use "phantom" circuits of which the simplest case would be in a cable containing two pairs of wires, each of which pairs constitute a single circuit, while a third circuit is obtained by using each *pair* as one side of the additional or "phantom" circuit.

Naturally this involves a little more complication in the receiving and sending circuits, but the added cost is small.

Next came "carrier-current telephony" in which perhaps twenty-four communication channels could be obtained on one pair of wires. The terminal equipment in this case is far more elaborate, but is still not so expensive as laying additional cables.

In the next stage the old style of cable containing a large number of pairs of wires is replaced by a "coaxial" cable which contains almost nothing. It is simply a metal tube containing a single wire running down the centre, supported in the tube by insulators at regular intervals. The first cable of this type was laid between London and Birmingham, and by carrier-current methods will provide several hundred channels.

Now, if the wave-guide comes into use, the tube will be completely empty. The terminal equipment will be much more elaborate, but owing to the high frequencies used, a very large number of channels could be accommodated. When this system of piped radio is brought into general use, it will be true to say that the first step in setting up a new radio link is to call in the plumber.

Clinical Science: *Ancient—*

Researches into archaeology, anthropology, and geology have shown that disease has existed practically since the beginning of life on the earth. Evidence has been found that animals called sea lilies, some of which existed 4,500,000 years ago, were infested with snail-like parasites. Fossils of many of the early inhabitants of the earth, the

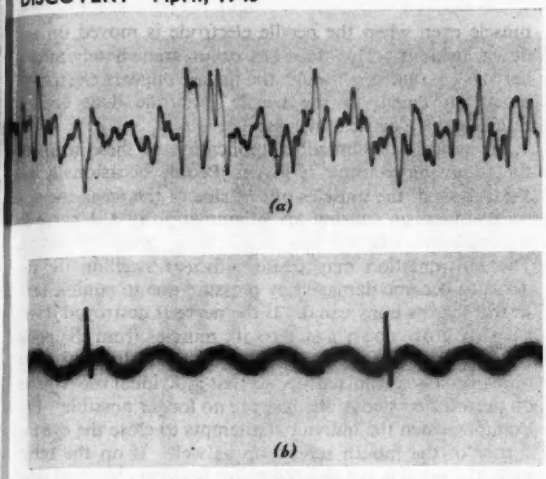

FIG. 1—Tracings of the electrical impulses of muscle —(*a*) From a normal muscle showing the impulses of the groups of muscle fibres; (*b*) From a muscle which has had the nerve cut showing the impulses given by contraction of the individual muscle fibres.

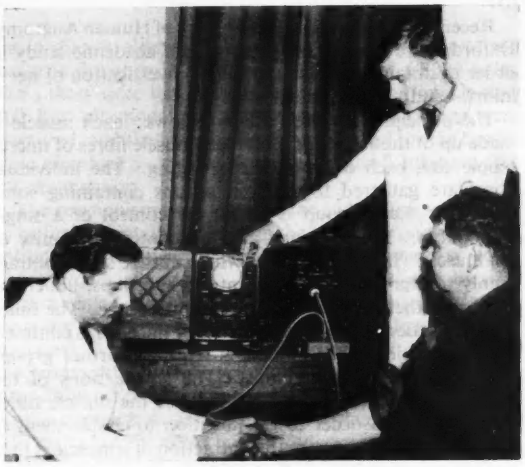

FIG. 2.—The apparatus used in recording the contractions of muscle groups.

ancient fishes and reptiles show signs of disease such as decayed teeth and infections of bones.

Man seems to have been attacked by disease as soon as he appeared on the scene. The Java man, believed to have lived 500,000 years ago, had a disease of his thigh bone; the famous Piltdown skull found in Sussex showed signs of glandular disease; the Neanderthal man, who lived something like 75,000 years ago, showed signs of rickets.

The oldest written record of the methods of treatment of disease which has come down to us from the ancient Egyptians dates from about 3000 B.C.

Prayers for assistance from gods and heroes, often combined with some sort of practical treatment, played a large part in their curative measures.

A prayer to Isis runs, "May Isis heal me as she healed Horus of all the ills inflicted upon him when Set slew his father Osiris. O Isis, thou great enchantress, free me, deliver me from all evil, bad and horrible things, from the god and goddess of sickness, and from the unclean demon who presses upon me, as thou did loose and free thy son Horus."

Incantations were a favourite method of treating disease and some of them have been transmitted into modern folk medicine, The most famous ancient incantation was the "Abracadabra" incantation. The word was repeated, each time leaving out another letter, until only one syllable remained. It ran something like this:

Abracadabra
Bracadabra
Racadabra
Acadabra
Cadabra
Adabra
Dabra
Abra
Bra
Ra
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In addition to incanting this curious word and its modifications, the ancients often wrote it in the form of a pyramid, and bound the writing round the neck of the sufferer. This was worn for nine days and was then removed and thrown into a stream running eastwards.

This was supposed to be especially effective against fever.

A famous mediaeval incantation against fever had to be recited on St. Agnes' Eve by the eldest female in the family. It ran:

Tremble and go, first day shiver and burn,
Tremble and quake, second day shiver and learn,
Tremble and die, third day never return.

The casting out of evil spirits by cajolery, intimidation, or rather more violent means has been practised by people of all ages and in all stages of civilization.

Special faith has been placed in amulets such as precious stones, human hair, and extracts from sacred books. One curious charm dating from the first century A.D. is to put a spider in a nutshell and to wear it round the neck. This was believed to be a sure cure for the ague.

—and Modern

UP to recent times there has unfortunately been a divergence in work and attitude between pure science and clinical medicine. On the one hand the pure medical scientist often tends to lose sight of the ultimate aim of medicine, which is to prevent and cure physical and mental disease, and to concentrate too much on the academic side. On the other, the practitioner is faced with a situation in which many variable and uncontrollable factors are involved and he tends to rely mainly on his experience and intuition, often missing the opportunity of applying more precise methods of analysis which might be evolved from results obtained by scientists.

This situation is steadily improving, and it is in the realm of diagnosis and treatment that the greatest advances of clinical science may be expected.

Recently workers at the Department of Human Anatomy, Oxford, have applied the principles of academic study in order to obtain a precise method of investigation of nerve injuries and muscle paralysis.

The principles involved are as follows: each muscle is made up of thousands of individual muscle fibres of microscopic size, each capable of contracting. The individual fibres are gathered together in groups containing some hundreds. Each group is under the control of a single nerve fibre. These groups are the contracting units of the muscle. In order that the whole muscle shall contract evenly to a greater or less extent, these groups, under the control of their nerves, contract intermittently. The fuller the contraction of the muscle the faster the groups contract. If a still stronger contraction is required further groups start intermittent contractions. The contractions of the muscle groups are intermittent because the muscle fibres require a rest in order to get nutrition to enable them to contract again. The smooth contraction of a muscle is thus due to the cumulative effect of the myriad contractions of the individual groups. If, for example, all the groups of a muscle contracted at the same time there would be a sudden uncontrolled jerk. An increase in tension is determined by the *rate* at which the groups contract.

The contraction of each group is accompanied by an electrical discharge. Each of these discharges can be picked up individually by inserting a fine needle electrode into the muscle. The electrical impulses are very small and have to be amplified before they can be recorded.

The recording of these electrical impulses has been achieved by using an amplifier such as is found in a wireless receiver. The amplified impulses are led to the screen of a cathode-ray oscilloscope of the type employed in television receivers. When the impulses are very rapid the eye may be unable to analyse them in detail. For this reason the amplified impulses are also led into a loud-speaker where they give rise to characteristic sounds, the slightest variation in which is readily detectable. For very accurate work photographs of the images may be taken on a moving strip of film. It is thus possible to see and listen to a muscle contracting.

When the nerves to a muscle have been cut, the muscle becomes paralysed and gives off no electrical impulses for a period of some days. After this, however, electrical impulses of another sort can be picked up from the muscle, but they are very different from those obtained from a muscle still under the control of its nerve. They are very much smaller and repeat rhythmically. It has been shown that they are produced by the spontaneous contraction of the individual microscopic muscle *fibres* and not by muscle fibre *groups* as in a normal muscle.

It can be seen therefore that the state of the nerve supply to a muscle can readily be determined. If a muscle which has been paralysed for some days is giving off no electrical impulses it is clear that the nerve, although it is not working, is intact. On the other hand if tiny impulses indicative of the spontaneous contractions of the individual muscle fibres are present it is equally clear that the nerve to that muscle has been damaged. In this way it is possible to get information regarding the state of nerves which have been subjected to injuries or affected by disease.

Sometimes muscles themselves degenerate, and in those cases no electrical impulses can be obtained from a muscle even when the needle electrode is moved up and down inside it. This does not occur immediately after a nerve is cut, when, although the muscle appears electrically quiet, movement of the needle electrode does elicit a discharge of electrical impulses.

To indicate the practical application of these methods the following example is given. People occasionally get a paralysis of the muscles of one side of the face, due to a micro-organism causing an inflammation of the nerve to those muscles where it travels in a bony canal to the skull. The inflammation may cause sufficient swelling for the nerve to become damaged by pressure due to confinement in the narrow bony canal. If the nerve is destroyed it will have to grow down again to its muscles from the point where it was damaged. In so doing the individual nerve fibres usually get mixed up, so that individual movements on the affected side of the face are no longer possible. For example, when the individual attempts to close the eye the corner of the mouth screws up as well. If on the other hand the nerve is not destroyed but is merely blocked temporarily by the pressure, normal movements return. By the use of the apparatus described it is possible to tell at once whether the nerve has been destroyed or blocked. If the nerve has been destroyed the patient must be warned what to expect and treatment must be started to keep the muscles in good condition so that they will be ready to receive the nerve fibres when they finally do grow down to them. On the other hand, if the nerve is only blocked complete functional recovery can be expected. Recently a number of surgeons have been treating this type of case by opening the bony canal in which the nerve runs so as to allow room for the swelling and thus possibly avoid damage to the nerve by compression. Unfortunately a number of these cases have been operated on when the nerve is already destroyed, an unbeneficial procedure. The value of a precise diagnosis in such cases is clear.

Electron Meets Insect

EVERYONE has seen the beautiful iridescent colours, often brilliant greens and blues, which are displayed by certain species of beetles and butterflies. These adornments which serve to attract the opposite sex, cannot be due to ordinary chemical pigments, which merely reflect a particular colour from the light that falls on them, The change of brightness which flashes out like a jewel in the lamp light when the light falls on the insect at the correct angle shows that there must be some special microscopic structure at work. Workers in optics have long made use of this principle for the formation of spectra and other purposes. A ruled "grating" of very fine parallel lines, ruled on glass at a constant separation which is about the same as the wavelength of light will exhibit just such effects.

It might be expected that a more detailed examination of the microscopic structure of the wings and wing-cases of these insects would show just such a minute geometrical structure. Unfortunately, a difficulty presents itself immediately. An ordinary microscope can never display this structure, since the microscope uses light to show up the objects which are viewed through it. If we wish to study a structure smaller than the wavelength of light we can never achieve our purpose by means of even the most

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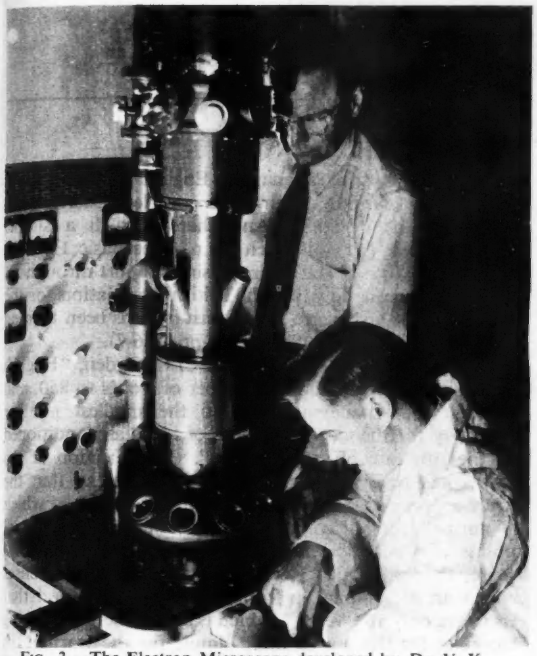

FIG. 3.—The Electron Microscope developed by Dr. V. K. Zworykin (*standing*), Dr. James Hillier (*seated*) and Mr. Vance, and constructed by the R.C.A. Manufacturing Co. of New York. Seven of these microscopes have recently arrived in this country under Lease-Lend arrangement.

powerful microscope, simply because the structure is too small to disturb a train of light waves.

It is here that a new instrument which has only recently been invented is brought to our aid. The fundamental theoretical work of the French physicist, de Broglie, who unified the theoretical treatment of light waves, and of the waves which we now know are associated with movement of electrons, has made it possible to use a beam of electrons to study structures which are too small to be seen in an ordinary microscope. This possibility arises because de Broglie was able to show that the waves associated with a beam of electrons were very much shorter than those of light, and would therefore be disturbed by very much more tiny objects.

The electron microscope which is based on his work and has been mainly developed in the laboratories of the Radio Corporation of America has been applied to the study of a great variety of tiny organisms, including the viruses which are responsible for many diseases, bacteria, and so on.

Recently Dr. Thomas F. Anderson and Dr. A. Glenn Richards, working at the University of Pennsylvania and in the R.C.A. Laboratories have turned the electron microscope to the study of the iridescent wing structures of beetles and butterflies.

The specimens investigated were the wing of the beetle *Serica Sericea*, and the wing scales of the blue butterfly *Morpho Cypris*. The method adopted in this kind of research is either to photograph the specimen itself, or in other cases a "replica", i.e. a mould made out of gelatine or collodion shaped on the specimen to be studied. Some of the structures were too thick to be photographed on the ordinary electron microscope in which the electron beam is driven by a potential difference of 60,000 volts, and others were too even thick to be studied on the new 300 kilovolt model. In these cases the specimens were fractured, and the broken edges were studied, or the tissues were dissolved away leaving the "skeleton" structure free for examination.

The mechanism which caused the iridescence was found to be fundamentally different in the two cases under investigation. On the wing of the beetle a succession of equidistant ridges was found. These were spaced at a distance of just under $\frac{1}{1000}$ of a millimetre which is rather longer than the wavelength of the reddest visible light. Such a structure is similar to the diffraction grating used by spectroscopists, which splits white light falling on it into its constituent rainbow colours. Since the beetle's wing is curved it shines in all colours when a beam of light falls on it, but the effect is not produced in diffuse light.

The structure of the scales of the Morpho butterfly is rather more complicated. It consists also of equidistant ribs, but these ribs are equipped with bundles of vertical vanes, which in turnare sub-divided by horizontal thickenings or "mullions". It can theoretically be shown that light reflection off such a system of equally spaced mullions must produce the same selective reflection which occurs in a soap bubble when the wall thickness has reached half the wavelength of light.

The blue iridescence could be explained if the distance between the mullions was $\frac{1}{5000}$ of a millimetre, i.e., half the wavelength of blue light.

However, it was found that the distance shown in the photographs was only $\frac{1}{8000}$ millimetre. This discrepancy was accounted for when it was observed that the electron bombardment had evidently shrunk the structure of the wing. After bombardment in the microscope the formerly blue wing scale had turned black, which is only to be expected since the distance of $\frac{1}{8000}$ millimetre cannot account for any reflection in the range of visible light. It is, however, possible to alter the optical properties of such a structure artificially, and when alcohol was allowed to flow on to a blue wing, its colour changed to an iridescent yellow, because the scales absorbed the alcohol and swelled up, thus altering their effective spacing.

If alcohol was poured on the wing blackened by electron bombardment it assumed a purple colour which showed that the treatment with alcohol had brought the optical properties of the scale back to the visible range and that the electron bombardment, while shrinking the structure, had not destroyed it.

Such experiments are of very considerable value in the stage when scientists are learning the technique of employing a powerful new means of investigation. At a recent meeting at the Royal Institution, Sir Lawrence Bragg announced that there were now seven electron microscopes in Great Britain, and we may therefore expect interesting and valuable work on this side of the Atlantic.

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Basic English and Science

G. C. AINSWORTH, B.Sc., Ph.D.

IT is common knowledge that the output of science writing is very great and is increasing. In the current (1934) *World List of Scientific Periodicals* there are the names of about 25,000 different journals and so on kept by 187 important libraries in the British Isles. By the year A.D. 2,000 there will, in the opinion of Van Dokkum, be not less than 24,000,000 books and 300,000,000 papers on science in general. Most of these papers, and to a lesser degree the books, will give detailed results of investigations. This being so, printing for use in one country is not enough. The investigations recorded will have been in some degree uncomplete if the papers are not seen by all others who, wherever they may be living, are interested in testing or using the results. The questions of how all workers in one field may best be kept in touch with one another's investigations, and how the discoveries in one branch of science may best be put to use in another, are very complex. Wise adjustments in how and where results are printed and better "abstracting" organizations would do much, but a complete solution is not possible without doing something about the language difficulty.

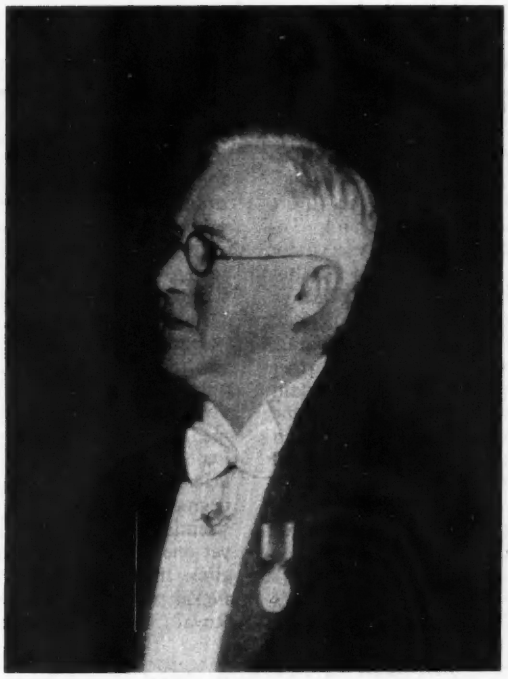
Under the International Rules of Botanical Nomenclature, the first account of a new plant has to be in Latin, but to-day Latin, which was at one time the international language of men of science, is little used. In the last two hundred years the greatest development of science has been in the West, so that the three languages most used for science are English, German, and French. Between 1850 and 1900 almost all important science writing was in one of these three languages, but in the past fifty years there has been a marked expansion of science in the East and in the smaller countries of the West, so that an increasing amount of science writing is now being done in other languages. The position is that a man of science who does most of his reading at first hand and who in the past had to have a knowledge of three languages, now has, in addition, to get a knowledge of at least twenty other languages. So the need for an international language becomes clear.

It might be possible to get an agreement for all science writing to be done in English, German, or French, but it is no simpler for a Russian, for example, to get a working knowledge of *one* of these three languages than for a German or Frenchman to get a knowledge of Russian; and Russian is the first language of a greater number of persons than is German or French. It might be possible for some language such as Esperanto to be taken up, but so far there is no language of this sort which would have the approval of the nations of the East and the West. It might be possible to make English the language of science, but it is very uncertain that other countries would give their support to a suggestion for the use of English as such. English, however, is the chief language of science; it is the natural language, or the language of the government, of about 600,000,000 persons, and it is the second language of the East. A simple form of English, a form which even those whose natural language is English would have to give time to learning, might be a complete international answer to the question. And there is such a simple English in existence, of which the name is Basic English; a language which is getting increasing support throughout the Earth and one to which the British Association for the Advancement of Science has in past months been turning its attention (see *Adv. Sci.*, 1942, pp. 256-7).

Basic English is, in the words of C. K. Ogden, "English made simple by limiting the number of words to 850, and the rules for managing them to the smallest number necessary for the clear statement of ideas as conditioned by the structure of the language". The selection of the words has been made with very great care, so that the 850 words are able to do the work of the 20,000 of which a normal person commonly has knowledge. Special points of Basic are that every word has only one root sense, though it may have one or more further senses which are developments from the root sense; and that there are only 18 "verbs", which is a great help in making the rules for the use of Basic simple for the learner. In addition to the Basic selection there are international words; words which are the same in all languages. In general Basic there are at present 50 words (such as *alcohol*, *bar*, *club*, *telephone*, and so on), which seem to be truly international. For science, however, a word is taken as international if it is the same in English, German, French, Spanish, Italian, and Russian, though words only different in Russian, and probably clear to a Russian man of science, may be used as internationals. There are hundreds of special science words which are international in this sense, but a little expansion of the Basic list is necessary before full use may be made of these international science words. In *Basic for Science* (printed last year) 100 general science words are given, and in addition there are lists of 50 words for special branches of science. In biology, for example, it is necessary to have a knowledge of the 850 Basic words, 100 general science words, and 50 special biology words, if full use is to be made of international words. A person with a knowledge of these 1000 words is able, with the help of international science words, to put on paper complex ideas and results, and if at times the writing has not, to an Englishman, the polish of complete English, Basic English is, in the hands of an expert at least, a natural-sounding and not unpleasing second language for the exchange of facts and experience.

[In this experiment in Basic writing there are only two non-Basic words (*abstracting* and *verbs*) and two international science words (*journals* and *result*) in addition to words from the Basic and General Science Lists.

The following are examples of science books written in Basic: *Basic for Geology* and *The Growth of Science* by A. P. Rossiter; *A Basic Astronomy* by S. L. Salzedo; and *Inventions* (a Pelican book), *European Science* and *What Things are Made of* by H. Stafford Hadfield.]



Sir Henry Dale

PRESIDENT OF THE ROYAL SOCIETY

WILLIAM DICK

LAST autumn Sir Henry Dale handed over the direction of the National Institute of Medical Research, for which he has been responsible since 1928, to his successor, Professor C. R. Harington. He had reached his sixty-seventh birthday and doubtless looked forward to a comfortable retirement. But as things have turned out his life was to continue to be as busy as ever. The cloak of the late Sir William Bragg has fallen directly onto his shoulders, for as well as succeeding that much beloved scientist in the presidency of the Royal Society, Dale now fills other gaps that were left by Bragg's death. He has become a member of the scientific advisory committee to the War Cabinet, director of the Royal Institution, and chairman of the British Council's science committee. At his request his post at the Royal Institution is a temporary one. Before accepting it he expressed the wish that after three years the managers of the Institution should be free to consider their future policy. Dale is also a member of the Medical Research Council, and chairman of the governing board of the Lister Institute. He was elected an F.R.S. in 1914, and from 1925 to 1935 he was secretary of the Royal Society.

Dale's life work has been a fruitful combination of original research and administrative duties, for no less important than his own researches has been his contribution to the integration of medical research in this country. Dale, the son of a London business man, went to Cambridge to obtain a medical degree, but after graduating in zoology and physiology he did two years' research work in the physiological laboratory at Cambridge under Dr. J. N. Langley before proceeding to the clinical part of his medical course at Bart's. While gaining his medical degrees—he qualified as a doctor of medicine and a B.Chir.—he continued his research in physiology under Professor Starling at University College, London. It was there that his lifelong friendship with Otto Loewi started, with whom in 1936 he was to share the Nobel Prize. Next Dale went to Frankfurt-a-M. to study the new science of chemotherapy, whereby disease germs could be laid low by chemical bullets, under Paul Ehrlich of salvarsan fame. 1904 saw him back in England and a pharmacologist on the staff of the Wellcome Physiological Laboratories. Two years later he was a director of these laboratories, a post which he retained until 1914.

As Research Worker

In 1913 he took the first step on that march of research which was eventually to show the way in which nerves act by the emission of chemical messengers. When he

started his investigations it was clear that it was no use attempting to lay down the dosage of the drugs used in medicine without understanding the full physiological effect that the various drugs produced on the human body. In choosing ergot to analyse physiologically, Dale was as fortunate as was Mendel when he chose the pea for his experiments. The characteristic gross effect of ergot Dale found to be due to two alkaloids, ergotoxine and ergotamine. But ergot extracts produce incidental effects, not overtones of the alkaloid effects, but themes in an altogether different key, to use a musical analogy, which a lesser man than Dale might have been tempted to neglect. Out of the complex of ergot Dale soon managed to separate two other chemcals, tyramine and histamine, and further investigations showed that the latter played an important part in the phenomenon of shock. Histamine is one of the most potent substances in its physiological effect. Half a milligram, for instance, is enough to kill an average sized guinea-pig, and one part of histamine in 25,000,000 can now be detected physiologically.

Then in 1914 Dale traced another chemical in ergot extract. This was acetylcholine, which Dale and Dudley later found to occur in the animal body. In 1921 Loewi, working independently though well aware of Dale's work, showed that the vagus nerve exerted its characteristic effect upon the heart—when the vagus is stimulated there is a slowing-down of the heart-beat—by the release of a chemical agent. Dale immediately suspected that this agent was acetylcholine, although it took him eight years to prove it. The researches of Dale and Loewi, which were complementary to the highest degree, established that the action of nerves is closely associated with both acetylcholine and adrenaline, and it now seems that all motor nerves in mammals produce their effects by the local liberation of one or other of these two substances. This has led to a physiological classification of nerves into two categories—the Adrenergic, which give off adrenaline, and the Cholinergic, producing acetylcholine.

As Administrator

Now to Dale's administrative work. The Act of 1911 established not only the present system of health insurance but a State organization for medical research, for which an advisory body was set up—the now famous Medical Research Council. With the formulation of research projects under the Act, one of the first laboratories to be established was the National Institute for Medical Research. It was started in 1914, with Dale as director of the pharmacology and chemotherapy section. A month later the Great War began. Some of the plans for the Institute had to be postponed, while the staff was diverted to various war-time duties and was not reassembled until 1920. After the war the Institute made magnificent progress, and one feels that Dale had in his mind the rapid flowering of research projects which had been "vernalized" so to speak by the chilling experience of the last war when he said recently, "When the smoke of war has cleared, knowledge will leap forward from new points of vantage." The Institute for whose development Dale as director was so largely responsible is to-day very important not only in the field of medical research, but also in the wider field of international medicine. To-day the centre is responsible for maintaining the international standards for various drugs (the arsephenamines and the heart drugs, for example), vitamins and hormones, which are the biological yard-sticks used for measuring the strength of medicaments, and determining the correct physiological doses which doctors can safely use. Since the occupation of Denmark by the Nazis, the Institute has also become responsible for keeping the international standards of antitoxins and tuberculin.

Medicine at the present time is at once a blend—not always a stable blend—of art, craft, and science. If medicine has become more scientific in the last 25 years Dale and his associates have done much to make it so. Science and medicine are like two circles which to a small degree overlap; Dale lies within the segment where scientists and medical men are on common ground, and yet one feels that he is nearer the centre of the scientific circle than the medical one. It is easier to see him as President of the Royal Society than as a Fellow of the Royal College of Physicians, although in fact he is both.

A Man of Vigour

What of Dale the man? Meeting him for the first time the description "aloof" almost automatically springs to mind. That aloofness is more apparent than real, for one of the outstanding features of his career has been his talent for *collaboration* with other scientists. Tall, grey and precise of speech, he has that air of objective detachment which one finds among specialists in many walks of life. If one talks to Dale about the progress in his branch of medical science one expects fine, historical details; listening to a lecture by him you would be as shocked by a matey anecdote or ironic quip from his lips as if he had injected you with a shot of histamine! Dale has indeed a very fine sense of the historical, which he used to good account in the speech he made at Grantham on the recent occasion of Newton's centenary. His recent lectures the Royal Institution on the history of pharmacology have been equally interesting, and form a basis of a popular book on the subject if he could make time to write one. If Dale is precise in his speech, he is also incisive. He bears his years well; indeed he seems to be a member of that happy band of men the vigour of whose thoughts and ideas do not slacken with the years.

Dale has one son, and of his two daughters the elder is married to Professor A. R. Todd of Manchester University. Since Dale became president of the Royal Society he has had the satisfaction of seeing his son-in-law, whose work on the synthesis of vitamin B_1 has placed him in the front rank of biochemists, elected an F.R.S.

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Courtesy of Portland Plastics, Ltd.

FIG. 1.—Hand, finger, ear and nose moulded in "Portex."

Whither Plastics?

V. E. YARSLEY, D.Sc., M.Sc., F.I.C.

DESPITE its somewhat unromantic and not a little misleading title, the plastics industry has risen in a remarkably short space of time from small beginnings to the rank of a major industry throughout the world. More correctly we should speak of the plastics industries, since in actual fact, quite apart from what may be termed the user industries, plastics include many scattered industries which time and the process of logical development have welded into a united whole.

In the world of commerce it is widely accepted that there is much in a name, and in spite of general early criticism, it is possible that the apparently paradoxical designation "plastics" has done much to arouse curiosity and its natural corollary, interest. To the layman the term plastic suggests materials such as pitch, putty, or the plasticine he used for modelling in his schooldays, and he finds it difficult to associate these materials with the moulded products he sees in abundance all around him to-day. The nomenclature is, however, not so illogical as it would first appear, since all the materials which we designate as plastics have at some stage in their history been capable of flow, and have indeed acquired their familiar everyday shape under the action of heat and pressure. This broad definition would obviously include many materials which cannot be classed as plastics, so that in the interest of precise statement certain limiting qualifications are necessary. All plastics are organic compounds, and with very few exceptions their backbone structure is built up from long chains of carbon atoms in association with hydrogen, oxygen, nitrogen, chlorine, etc. This explains the apparent impossibility of the statement we sometimes read, that plastics are produced from coal, air and water. They are not produced by any magical process of admixing these three ingredients, but by

chemical processes whereby the essential elements contained therein are selectively combined to yield a product of predetermined composition and structure. Whilst bitumastic plastics are included under the general heading of plastics, rubber is not included, since the rubber industry was firmly established before what may be termed the new plastics industry took definite form.

The remarkable properties of plastic materials can be attributed as much to their structure as to their actual composition. Whilst the various commercial plastics belong to widely differing chemical families, they are structurally very similar, since they are all built up from constituent elements linked together in long chains. Under the application of heat the relative mobility of neighbouring chains increases, and according to the degree of the heat applied these chains can be caused to slip past one another, a process which is greatly accelerated by the simultaneous application of pressure. When the pressure is withdrawn and the temperature is reduced the constituent chains once more become fixed relative to one another and the materials becomes solid. With some plastic materials this process can be repeated indefinitely, provided only that the temperature of decomposition is never reached. These materials are classified as thermoplastic, and they can be softened and re-softened by the repeated application of heat and pressure. In some cases, however, the continued application of heat serves to anchor the constituent chains relatively to one another. Once this anchoring—or "curing" as it is known in industry—has taken place, no amount of further heat and pressure will cause the material to flow. These are known as the thermosetting plastics, and their moulding cycle is a two-fold one, the first operation being that in which the material is caused to flow and take up the shape of the mould, and the second being the anchoring of the constituent chains to give a product which is both insoluble and infusible. Whilst there are many distinct families of plastic materials, they all fall into this broad classification of thermoplastic or thermosetting products.

Plastics is not infrequently referred to as a new industry, and indeed there is some justification for this. Whilst the commercial production of some of the pioneer plastics dates back to the middle of the last century, and indeed some of the chemical substances which constitute the bulk of commercial plastics to-day have passed their centenary, it was not until after the World War that the foundations of the plastics industry as we know it to-day were actually laid. Thus, whilst plastics may certainly be accepted as a relatively new industry, it has certainly some very old roots.

Raw Material Considerations

It will be shown that plastics are produced from raw materials which are widely distributed throughout the world. The industry thus knows no limitations of climate and raw materials, it is in fact a "footloose" industry. This does not mean that adequacy of raw materials need not be taken into consideration; indeed, war-time conditions in this country have stressed their importance as a controlling factor in various branches of the industry. Whilst the necessary raw materials can be obtained almost anywhere in the world, certain countries are more favourably placed than others. Hitherto in this country the tendency has been to buy in the cheapest market, frequently to the detriment of the development of our potential resources. The outstanding example of this has been our failure to develop coal as a raw material for plastics, an omission which has seriously handicapped our production of hydrocarbon plastics.

The natural raw materials for plastics are many and widespread. Coal, oil, and natural gases are capable of supplying many of the raw materials needed for the production of hydrocarbon plastics such as styrene, vinyl, and acrylic acid derivatives. Coal also yields phenol and the related products used widely in the production of thermosetting resinoids. Urea, of interest to the chemist as being the first organic substance synthesized from inorganic constituents, is produced synthetically from ammonia and carbon dioxide, whilst formaldehyde, another coal-based product, is produced synthetically from carbon monoxide and hydrogen. Cellulose, the basis of the cellulose ester and ether plastics, is used in the form of cotton linters, which are the second cut of fibre from the cotton seeds after the long spinning fibre has been removed. Cotton linters for plastics and rayon is mainly of American origin. Good progress had been made before the war in the use of wood pulp for the production of both esters and ethers, but their use is only possible so long as there is a definite price advantage.

The changing fortunes of war have in recent months emphasized, as could nothing else, that raw materials are among the most important factors in controlling the future development of plastics. America and Germany have developed their natural resources to the full to meet the raw material requirements of their plastic industries, and there are indications that the same is true of Russia. There are welcome indications in this country that self-sufficiency in raw materials, even if it means entirely new process working, will be the keynote of post-war planning in the British plastics industry.

The Plastic Materials

Cellulose nitrate plastic, now known all over the world as "Xylonite" or celluloid, was the first to be produced on a commercial scale. Alexander Parkes took out his initial patents for this new material which he called Parkesine in 1855, and worked-up samples were shown at the Great Exhibition in London in 1862 and at the Paris Exhibition in 1867. In spite of the many changes through which the industry has since passed, this grand old pioneer has maintained its position over nearly a century of progress. Attempts to produce a celluloid-like material which would be less inflammable than celluloid resulted in the development of cellulose acetate plastic in the early days of the present century. Early efforts to produce this commercially met with indifferent success, and it was not until the post-war period, with the establishment of the acetate rayon industry, that a satisfactory plastic was marketed. At the end of the last century also came the production of a hornlike plastic from skimmed milk known as casein, sold in this country under such trade names as Lactoid and Erinoid. About the same time plastics derived from bitumen, asphalt, and pitches were developed by the electrical industry for insulating purposes. It will be noted that in the production of all these materials use had been made of

naturally occurring raw materials such as cellulose, rennet casein, and bitumen, which had the desired chain-like structure.

Early in the present century a change occurred which altered the outlook of the organic research chemist and was ultimately responsible for laying the foundation of the plastics industry as we know it to-day. Leo Baekeland, a Belgian-born American who had already been responsible for producing a photographic printing paper of world-wide fame, showed that resinoid materials could be produced by chemical synthesis. By condensing phenol and formaldehyde under specified conditions he obtained a resinous mass which, if sufficiently heated, became insoluble and infusible. Hitherto chemists had been obsessed with the beauties of the crystalline state, and it was customary to abandon products which could not be isolated in a satisfactory liquid or crystalline form. The researches of Baekeland and his contemporaries set a new fashion in organic research, and formed the basis for what is now an industry of considerable magnitude the production of thermosetting plastics of the phenolic or "PF" type.

Developments in this direction were extended in 1924 by a Viennese chemist named Pollak, who obtained products having properties very similar to those obtained by Baekeland by condensing urea with formaldehyde. These urea plastics, or aminoplastics as they are now more generally called, were superior to the phenolics in respect of their colour; indeed they are produced to-day in grades which are almost glass-like. Round these two great families of thermosetting plastics a considerable industry has been built up. It was assumed that these new plastics would replace the pioneer thermoplastics, but experience has shown that more usually these materials are complementary and not directly competitive in their commercial applications, and with the using public becoming more plastics conscious, the new and old have developed together at an increasingly rapid rate.

Once the possibility of building up resinoid materials from relatively simple chemical substances had been accepted by chemists and manufacturers, many long-neglected avenues of research were re-explored with marked success. Many products which dated to the pioneer days of organic chemistry almost a century ago, and which commerce had labelled as useless because they tended to give resinous masses which could not be easily worked, were now examined with a renewed interest. Simply hydrocarbons and their derivatives such as isoprene and butadiene had long been found to yield rubber-like products, but they had little opportunity to compete commercially with natural rubber. Further careful examination showed that by controlled molecular aggregation of many of these, products could be obtained which could be varied at will from granite hardness to rubber-like consistency. Thus intensive research laid the foundation for what may be termed the new thermoplastics derived from styrene, acrylic acid, vinyl chloride and their related products. Considerable additions have been made to our knowledge and application of these materials during the past ten years, and some members of this family have attained even more importance since the war in the Pacific has robbed the United Nations of the bulk of their supplies of natural rubber.

The production of the synthetic thermoplastics during the past decade has opened up an entirely new phase in the development of plastics. The chemist has become architect as well as builder. He has shown that he can not only select the chemical bricks from which he will construct his plastic, but to some extent at any rate he can control the arrangement of his structure. Not only does he build up the long molecules, but as Carleton Ellis so aptly said, he can now "tailor" them at will. An outstanding example of this is the work of Carrothers and the Du Pont chemists which resulted in the production of the nylon plastics. By interacting certain organic acids with amino compounds and polymerizing the products, remarkable raw materials have been obtained for the production of fibres, bristles and plastic products, sheets and films. The production of the nylon products is an epic of long-term chemical research.

Thus from small beginnings has grown up the plastics industry as we know it to-day. The new and the old have developed together, and in many instances recently gained knowledge has been applied with success to chemical products of a bygone age. The thermosetting and thermoplastic products, those derived from naturally occurring raw materials and those built up by chemical synthesis, are now applied on a scale far exceeding the dreams of the pioneers. Contemporary success has shown that even now we have but touched the fringe of the ultimate possibilities for these modern materials of construction.

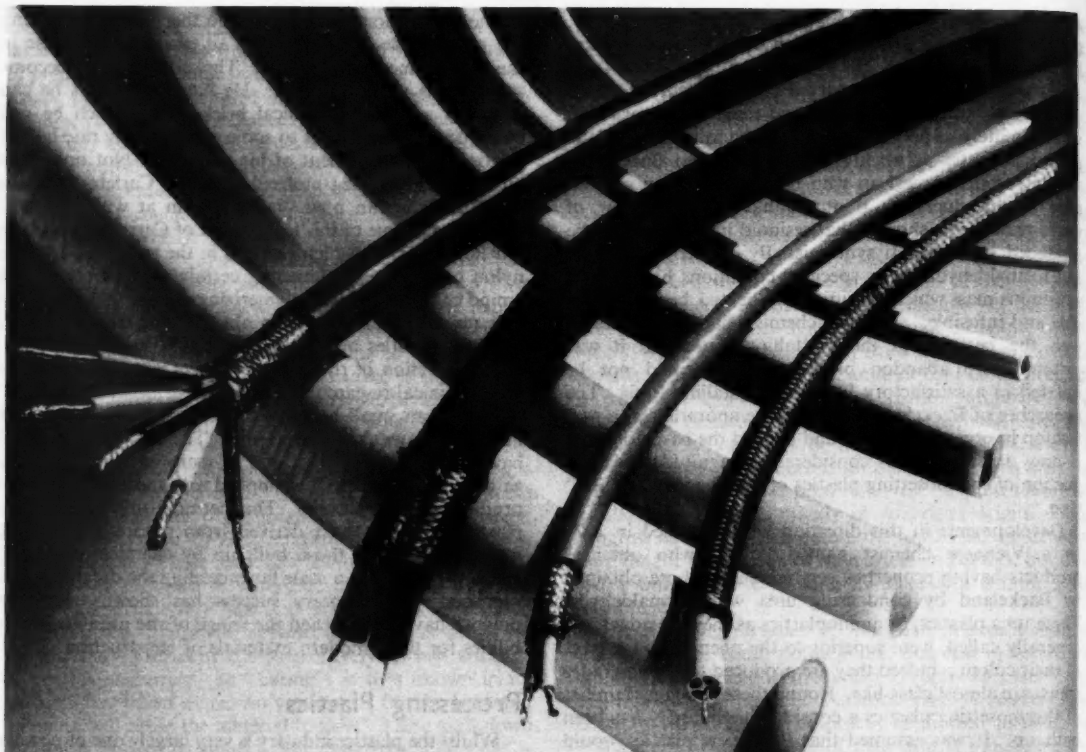
Processing Plastics

Whilst the plastics industry is very largely one of powder and press, this is not entirely true, since an increasing weight of material is worked from sheets, rods, and tubes which are manipulated under the action of heat and pressure to yield products of the desired shape.

Powders for moulding are prepared by incorporating the raw plastic with a modifying or plasticizing agent to give it the desired flow properties, and with colouring materials and fillers in the case of thermosetting powders. These are then reduced to finely comminuted form, or are compressed into pellets of predetermined size.

Sheets of plastic, notably of the thermoplastic class, are prepared by slicing from consolidated blocks of the plastic material, or they are produced by casting or pouring the plastic in liquid form on to a suitably polished surface. Yet again they may be produced by extruding the plastic in dough form through a suitable orifice and stoving the resulting sheets to remove residual volatile material. Sliced or extruded sheets are finally polished by pressing at elevated temperature between highly polished nickel sheets. The extrusion technique has been considerably extended in recent years and is now applied to the continuous processing of both thermoplastic and thermosetting materials. Tubes and rods of almost any regular geometric section can now be extruded.

Constituting what are virtually separate industries comes the use of reinforced plastic in the form of tube, rod and sheet. A suitable fibrous carrier of paper or fabric is impregnated with a thermosetting resinoid, usually a "PF" material, and the resulting sheets are united by heat and pressure to give what are known to industry as laminated plastics or just laminates. In some cases



Courtesy of Tenaplas Ltd.

FIG. 2.—Extruded plastic for cable manufacture.

wood is the reinforcing "carrier", the resinoid being used to replace the natural moisture and ligenous materials to yield a densified wood which has enhanced physical properties. In another variation resinoid bonding agents are used to unite thin wood veneers, to give materials long known to us as plywoods, but showing vastly superior physical properties to the earlier products in this class with their water soluble bonding adhesives. All these materials are being widely used in many varying fields of constructional work, aircraft, motor-cars, shipbuilding, industrial plant, furniture and even houses.

Plastic materials in powder form are converted into moulded products by processes of compression or injection moulding. In the former, which is more usually applied to thermosetting plastics, the required amount of the powdered or pelleted plastic is introduced into the mould and is subjected to elevated temperature and pressure sufficient to cause the plastic to take up the contour of the mould and to effect the necessary "cure" in the case of thermosetting plastics. Injection moulding, which is applied mainly to thermoplastic materials, differs from compression moulding in that the plastic is first liquefied and in this condition is forced under high pressure into a chilled mould, which subsequently splits to permit the removal of the moulded unit. Rapid strides have been made in recent years in the technique of injection moulding, which represents one of the major developments of the plastics industry. Broadly speaking, compression moulding is applied to the production of large units up to the size of the moulded coffin, which at present is stated to be the world's largest moulding, whilst of necessity injection moulding is limited to the production of relatively small units. But a few years ago injection moulding was limited to the production of articles weighing only a few grammes, to-day the large "multishot" automatic injection machines are capable of turning out units weighing several hundred grammes, and finality has by no means yet been reached.

Plastics Applied

It has been said, with some degree of truth, that with the exception of cutting edges and surfaces which have to

withstand direct heating, plastics can meet all the material needs of mankind, including his clothing. Whether or not they could do this economically or would be able to compete with current materials is another matter. Even in pre-war days plastic materials were used in the construction of innumerable articles formerly produced in metal, wood, glass or ceramic, and the application has been intensified during the period of the war, although at present few details are available of some of the latest applications of these modern materials of construction. For the time being a halt has been called in the application of plastics to the peaceful needs of man, and the whole industry is at present in full battle dress, with drab colours replacing the rainbow hues of peace-time days.

Within the space of this short review it is impossible to do justice to the innumerable applications of plastics, so that brief mention can only be made of some of the more outstanding of its constructional uses. From the earliest times the electrical industry has contributed largely to the development both of plastic materials and of processes for manipulating them, largely because their remarkable electrical insulation is among the most outstanding physical properties of plastics. Many new materials have actually been developed specifically for their application as electrical insulators in the production of electrical fittings, and they have subsequently been applied to general moulding and constructional work. An interesting instance of this in recent days is the development of heat-resisting methyl silicones, designed to overcome one of the weak points of current plastics, their inability to withstand elevated temperature. It is not surprising therefore that we find plant for the production and working-up of plastic materials associated with many of the large electrical undertakings throughout the world, and frequently what commenced as a plastics department in pioneer days had eventually developed into an independent commercial undertaking.

Courtesy of Runcolite Ltd.

FIG. 3.—Runcolite Utility Ware.

Many instances of the application of plastics in the electrical, radio, and telephone industries will be familiar to every reader. Electrical fittings, switches and the like in bakelite or aminoplastic were among the earliest moulded units which came in contact with the general public, and with the passage of time these have multiplied so that to-day almost all housings for switchgear are of of moulded or fabricated plastic. The artistic telephones with hand microphones, and in particular the many coloured instruments of peace-time days, together with the complete fittings for telephone booths and exchanges are tributes to the versatility of plastics. Radio likewise has made full use of the new materials of construction, although the moulded radio cabinets have hitherto not met with the success which might have been anticipated. In this country this may have been due to the fact that instead of exploring the colour possibilities of plastic materials, manufacturers appear to have adhered slavishly to reproducing in plastics the effects normally obtained in wood. In the electrical, radio and telephone industries, the advent of new plastic materials with particularly advantageous electrical properties has in many instances effected a complete revolution in design, and even the casual observer will have noticed that during recent years many familiar articles have, in consequence of the use of plastics, become more compact and generally more attractive.

Among the industries still in the course of evolution which have taken a keen interest in the possibilities of plastics, particular mention must be made of the aircraft and motor-car industries. In this connexion it may be as well to refer to what is an all too widespread misapprehension with regard to the moulded plastic aircraft or motor-car, about which one so frequently reads in the lay Press. Loose publicity has frequently given the impression of moulded aircraft or cars rolling from gigantic presses much as do ash-trays or beakers. This is of course entirely incorrect, since in actual fact it is only sections and fittings which are moulded or fabricated in

Courtesy of B.X. Plastics Ltd.

FIG. 4.—Collection of articles made from cellulose nitrate, cellulose acetate and casein plastics.

plastic and assembled later. Transparent sheets of methyl methacrylate and cellulose acetate have been applied with considerable success in the fabrication of cockpit covers and gun-turrets for bomber and fighter planes, and there are indications that post-war cars will have similar fittings which will give real meaning to the term "sunshine roof" so long misapplied. The bodies of cars will also no doubt make more extended use of laminated plastic, and injection moulded fittings will make corrosion in bodywork a thing of the past.

Moulded plastics have long been applied in the fitting of ships, but there are indications that plastics will play a much more significant part in the actual construction of ships in future. During the war considerable progress has been made in America in the application of laminated plastic and resin bonded sheet in the construction of small seacraft. In the construction of the new craft the technique developed for the use of plastics in aeroplane construction has been closely followed. Side panels, deck planks, bulkhead partitions, etc., are in plastic-bonded plywood, while for wind-shields and port lights transparent acrylic sheet replaces the heavier glass. The entire sides of these boats from the sheer to the chine are single panels of plywood. Honduras mahogany is the basic material and a special phenolic resinoid is the bonding agent. The laminated panels produced are 84 ft. by 8 ft., and are stated to be the largest known to the industry. These sheets are cut by the template and applied directly to the sides of the boats. The transom, which has rounded corners, is moulded in one piece, as are also the machine-gun turrets. The high-speed triple-screw motor torpedo boats thus constructed are from 70 ft. to 80 ft. in length, capable of carrying four 21-in. torpedo tubes, two twin 50-calibre anti-aircraft machine-guns and eight depth-charges; they are manned by a crew of ten men and can do up to 50 knots.

The considerable progress made in recent years in the production of resin bonded sheet materials is likely to be reflected in the part plastics may play in the post-war reconstruction period. Already the possibility of using plastics in the actual construction of houses has received the careful consideration of the authorities in various parts of the country, and actual trials to this end are now being carried out in Scotland. The shortage of materials and perhaps labour which we shall have to face in the post-war period will make it essential to adopt new materials and new methods to cope with this. Plastics are ideally suited to prefabrication methods, which alone would appear capable of meeting the demands of the present situation. The same will apply to house fittings and furniture. The advent of these new materials in the construction and fitting of our homes may mean entirely new standards in design; it has fortunately been realized that we cannot just reproduce in plastic the fittings or furniture which for many decades has been produced in wood or metal.

Coming to what may be termed the lighter industries we find that plastics are equally in evidence. Plastics of course have for years made possible the development of the two great public entertainers, the cinema and the gramophone. Apart from the cinema the photographic film has opened up untold possibilities in aircraft reconnaissance and X-ray work. Direct recording, which is the logical development of the pressed gramophone record, has in its turn given an entirely new meaning to radio propaganda.

In the field of dentistry, surgery, and medical science plastics have already achieved notable success which promises rapid extension. Resinoid dentures are of course no novelty, but the progress made in the past five years in the application of methyl methacrylate plastic in denture production is worthy of special mention. Not only the dental plates but also the actual dentines are now produced in this plastic, so that teeth and plate are one and the same structure. The resinoid dentures are light in weight and more comfortable to the gums, they are easily repaired and are definitely more natural in appearance. The recently restricted use of vulcanite in this country has resulted in a complete swing-over to the resinoid denture, and it is fairly certain that once they are tried they must continue in favour.

Some interesting developments which are likely to have the far-reaching effect on the application of plastics to medical science have recently been carried out in London under the general direction of Penelope Norris, and relate to the use of methyl methacrylate and similar plastics in the production of artificial limbs. Hands, fingers, ears and noses for facial restoration after war injury, accident or disease can be produced in plastic, and can be fitted in a few days and so eliminate much surgery which used to require up to twenty operations. These materials can also be used for the production of artificial joints where injury, rheumatism or other disease has destroyed bone and caused joint fixation. They are also being applied in the production of partial "skulls" known as "obturators" to replace bone and protect the brain when there has been gross loss of bone tissue. Plastic materials of the same general type are also applied in the production of internal splints for bone fractures. These are transparent to X-rays, and eliminate cumbersome external splints reducing the time for healing and immobilization. Bone callus formation is rapid with these splints and they may be left *in situ* permanently. These versatile materials may also be used for the production of flexible tough synthetic tendons for grafting into tissues and bones to enable restoration or function where burns and other injuries have destroyed them. The plastic material in solution form can also be sprayed as a protective or air-excluding layer over burns, and may also be used as a tough protective layer for application to skin after blood transfusions, thereby immediately arresting further bleeding.

In many other industries we find that plastics are making headway, and even where actual production may now be impossible, development work is going ahead for post-war production. The printing industry is finding that it has many outlets for the new materials in the production of actual type, blocks, printing rollers, machine frames and fittings. Toys in brightly coloured plastics are more hygienic, durable and safe. Many household articles and ornaments formerly produced in metal will emerge after the war in plastics. It is equally certain that plastics will set new standards in decorative trinkets and ornaments. Glass-like and brightly coloured plastics which are virtually unbreakable have already set new standards in display and packaging. Models in similar sheet plastic have proved the old adage that "seeing is believing". In this connexion considerable progress has been made in this

country in the production of working demonstration models in transparent plastic. By such means the internal working of relatively intricate mechanisms such as gears can be readily followed and explained.

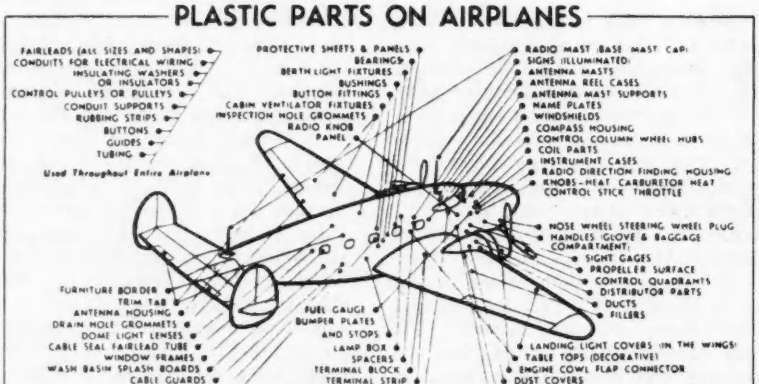
Quite apart from these industries in which plastics appear as sheet or moulded units, synthetic plastics find many less obvious applications. Few people realize that the remarkable surfaces now produced on furniture are due to the resinoid finishes which take a remarkably high polish. In actual fact a greater weight of synthetic material goes each year into the production of finishes, coating compositions and adhesives than into moulded plastic or sheet. Plastic material is extruded to cover fibre or webbing to give a material now used in the manufacture of "basket work" furniture. Certain resinoids applied to fabrics of many types render these materials resistant to creasing. Other materials known as "base exchange" resinoids are used in the purification of water. Widely separated processes and applications yet always the same fundamental raw materials—just plastics.

Comparative Statistics

In conclusion, just a brief statistical consideration of what we may call the economics of world plastics which may help us to view it in its correct perspective against the background of world trade. Authoritative data published in 1937 showed that the capital invested in the plastics industry in this country at that date was of the order of £5,000,000 sterling. Turnover was similarly given as £7,500,000, and this compared with coal £146,000,000, iron and steel £280,000,000, printing £106,000,000, and motor and cycle £136,000,000. In this connexion it may be interesting to compare the production in the three great plastics-producing countries—Great Britain, U.S.A., and Germany. The latest figures available, those published in 1937, were given as 27,500, 95,000, 65,000 metric tons respectively. If these figures are divided by the populations of the respective countries at that time we get the following figures for pounds of plastic per head of population: Great Britain 1.1, U.S.A. 1.45, and Germany 1.5.

Some idea of the progress made in recent years is given in statistics recently published in America. The production there of cellulosic plastics (cellulose acetate and celluloid) during the first four months of 1942, that is the first four war months for America, amounted to roughly 22,500,000 pounds weight, which is within a million pounds of the output for the whole of 1938. The total production of synthetic resins in America in 1941 is given as 438,000,000 pounds, this being an increase of 58% over 1940.

Thus briefly is the story of plastics, the story of the new materials of construction which have already done so much to revolutionize the life of every one of us. But the story is only just unfolding, and the actual extent of the progress made under the intense stress of war-time effort is shrouded at present under the smoke cloud of official secrecy. What the bounds of progress are likely to be no one can tell, but just as it can be said that in drab battle-dress these new materials have done much to aid the war effort, so they will have much to offer in the rehabilitation of a war-torn world, when they can emerge once again in their rainbow colours to bring pleasure and some measure of comfort into many drab lives.



Courtesy of the Editor of "British Plastics."

Science for Freedom: 1543-1943

S. LILLEY, Ph.D.

FOUR HUNDRED years ago in 1543 Copernicus dared to publish his book *De Revolutionibus Orbium Coelestium*, in which he expounded the startling theory that the earth moves round the sun, not the sun round the earth. For more than thirty years he had hesitated, fearing the scorn of the orthodox, and worse perhaps. He had circulated privately a brief account of his work, the *Commentariolus*, in 1512. But it was only after constant pressure from his friends that he dared to commit his views to print, and even then only at the age of seventy, when he had little to fear from authority.

In the same year Vesalius published his *De Humani Corporis Fabrica*, in which he too took a step of some daring. He uses the word himself: "Not long ago I would not have dared to turn aside even a hair's breadth from Galen. But the septum of the heart is as thick, dense and compact as the rest of the heart. I do not see, therefore, how even the smallest particle can be transferred from the right to the left ventricle through the septum"—contrary to the teaching of the said Galen, which had been accepted as infallible for thirteen centuries.

It is difficult to conceive nowadays that any inordinate bravery should have been involved in these two actions. Yet they began a struggle for scientific freedom which was not to be completed for more than a century. Copernicus probably over-rated the danger of publishing his work, but fifty years later his fears would have been more than justified. For by then scientists who dared to repeat the Copernican theory or break away in some other manner from tradition were in very great danger of bitter persecution and quite probably death, if they did not recant their opinions. One has only to instance Bruno (of whom more hereafter) burnt at the stake in 1600, or Galileo who was forbidden in 1616 to teach the Copernican theory, yet defied the order and was condemned in 1633 to imprisonment (albeit in very mild form) for the remaining nine years of his life. Not only did some scientists suffer for their opinions; others were sufficiently intimidated by authority to be afraid to declare their views—Descartes, for example, was about to publish his first book in 1633, when he heard of Galileo's condemnation and promptly withdrew the book.

It is of considerable interest, especially in view of the similar plight of science under Nazi Germany, to discover the reasons for this bitter persecution of those who sought for scientific truth.

Let us look a little first at the system of scientific thought that was current in sixteenth-century Europe and at the relations between that thought and the Copernican revolution. Perhaps thereby we may find what lay beneath the struggle.

Aristotelian Science

In physics and cosmology it was generally held at this period that all truth (apart from details) was to be found in the writings of Aristotle. And the Aristotelian philosophical system, both as stated by the Stagirite himself and as further developed by others, was primarily a teleological one. That is to say, it assumed that the Universe existed to fulfill a certain Purpose and that the existence and behaviour of all things could be explained with reference to that Purpose. Each object had its own purpose, which was merely a part of the Great Purpose of the Universe, and the explanation of every phenomenon was to be sought, not in its causes in a modern sense (the relevant events which preceded it), but in its Final Cause, that is, its place within the Purpose. The purpose of each phenomenon or train of phenomena was usually some sort of perfection, and once the particular sort of perfection involved had been assumed the rest of physics and cosmology followed logically.

In working out this philosophical system in relation to science, one of the main tenets of the Aristotelian cosmology was an absolute distinction between the behaviours of terrestrial and of celestial matter, the latter comprising everything lying beyond the sphere in which the moon rotated. The terrestrial part of the Universe consisted of four concentric spheres; these were the appointed places of the four elements, earth, water, air, fire, in that order outwards from the centre. In actual fact the four elements were very much mixed up together and so they continually tried to return to their proper spheres. That, of course, could be most directly accomplished by moving straight up or down. Hence, according to Aristotelian physics, the natural, the proper motion of terrestrial objects was rectilinear, either up or down, and any other type of motion was accidental and transient. But rectilinear motion had the imperfection that in the finite Aristotelian universe it could not persist for ever. Thus it followed that the celestial bodies, which are perfect, must move not in straight lines but in circles, a motion which need never cease. The earth, of course, was fixed and was the centre of these circles.

The celestial bodies were incapable of change (except in position), of generation and of decay. Instead of "There is nothing new under the sun", the Aristotelians held that "There is nothing new above the moon". Within the terrestrial sphere, on the other hand, generation and decay were admitted. But of terrestrial change a great part was due merely to the tendency of the elements to seek their proper spheres, a mere return of a disturbed system to an unchanging normal. The rest was frequently regarded as ultimately controlled in broad outline by the unchanging celestial spheres (this astrological side of the theory was greatly developed in the Middle Ages). Thus in the last analysis, an extreme version of the theory might regard all change in the earthly sphere as either an oscillation about an unchanging, proper, and appointed normal, or a mere illusion concealing the effects of the unchanging heavenly bodies. Such extreme views were probably never stated, but various approximations to them occur.

Reproduced from "History of Science, Technology and Philosophy in the XVIth and XVIIth Centuries" by H. Wolf, published by George Allen & Unwin, Ltd., London.

FIG. 1.—Portrait of Copernicus.

Copernicus' theory directly contradicted much of this cosmology. According to his ideas every object on earth took part in a circular motion due to the earth's daily rotation and in yet another arising from the earth's circular path round the sun. The natural motion for terrestrial, as for celestial, objects became circular (the seventeenth-century concept of uniform motion in a straight line except under the action of force was still a long way off). In this way the Copernican theory challenged the Aristotelian distinction between terrestrial and celestial physics. It put the earth on a level with the other planets and abolished all the superior perfection which had been attributed to the heavens and all the central uniqueness which had been attributed to the earth.

It was a long road from this point to Newton's universal gravitation and the conception of the whole universe as governed by the same laws that control the path of a cannon ball. Yet even on this road Copernicus took one step:

"I am of the opinion that gravity is nothing but a certain natural tendency to draw together, which is implanted in parts by the divine providence of the Maker of all things, that they may collect themselves into unity and completeness, being assembled into the form of a sphere. It is to be supposed that this influence resides also in the Sun, Moon, and other planets in order that, by its agency, they may remain in that globular shape in which they appear."

Copernicus does not conceive of gravity as acting *between* the heavenly bodies and thus controlling their motions, but at least he thinks of it as a universal property, not just a property of the terrestrial sphere, as Aristotle would have it.

It would be foolish, of course, to think that Copernicus was setting out to destroy the teleological mode of thought in physics. Far from it; his book abounds in teleological concepts: motions explained by their purpose and that purpose always some sort of perfection, as, for example, in the passage quoted above, where gravity was "implanted" in all things in order "that they may collect themselves into *unity and completeness*". Copernicus was breaking consciously with Aristotelian cosmology by removing the earth from the centre of the universe, but he kept as closely as possible to Aristotelian physical principles. Indeed, to refute the Aristotelian arguments against the mobility of the earth he himself used arguments which were equally Aristotelian, but inverted. Like Aristotle, he begins by asserting certain types of motion to be the "natural" ones; only they are different types.

But though Copernicus' own object was no more than to produce an astronomical theory which fitted observed facts (and could therefore be used to predict observations, for the benefit of the mariner among others), nevertheless objectively he was tearing large gaps in the Aristotelian defences and preparing, as it were, the bases from which Galileo and Newton were to smash those defences completely within a century and a half.

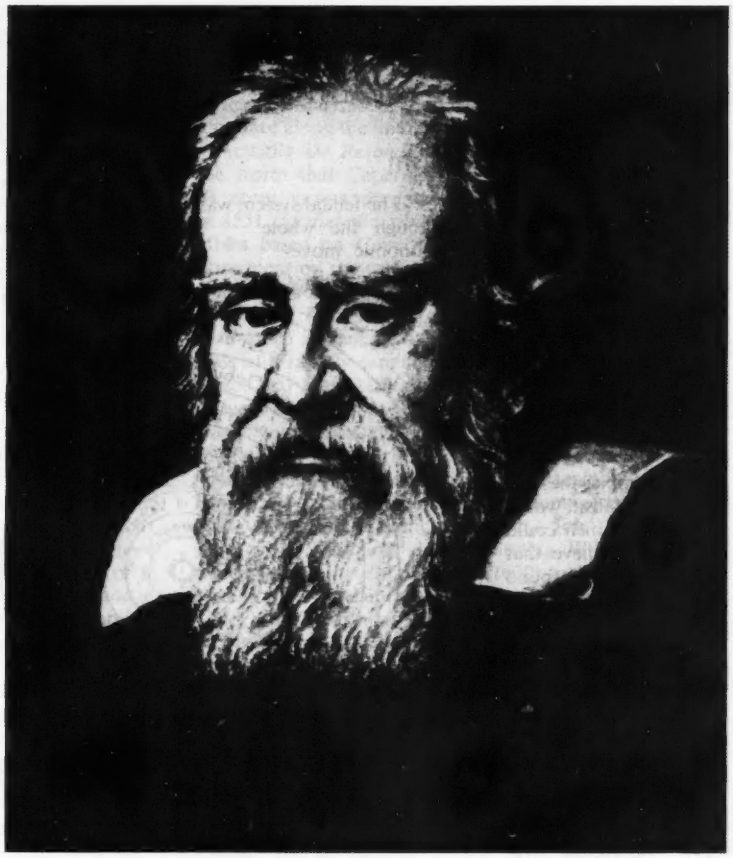
So far, so good. At least it is clear that the Copernican theory directly challenged much of the Aristotelian conception of the universe and that an even greater challenge was implied in the working out of the ideas which it introduced. But it is still by no means clear why the orthodox should have so bitterly persecuted those who followed the new ideas. Ignorant and bigoted men are far from glad to see their conception of the world destroyed in a flood of research, but they do not usually go to

such lengths as burning at the stake to prevent that destruction. Something more than scientific ideas must have been involved.

Was it simply that these scientific ideas were bound up with religious beliefs? Well, the evidence is against that. Most of those who suffered for science were at great pains to show that nothing they taught was at variance with the scriptures. And at other times the Church had been able to tolerate the discoveries of science without dislocation of its doctrine. In the thirteenth century, for example, the monasteries were the centres of research and the scientific work of men like Albertus Magnus, St. Thomas Aquinas, and Roger Bacon was just as startlingly revolutionary for the time as was that of Copernicus for the sixteenth century. Furthermore, the work of these men, especially of St. Thomas, was largely concerned with the introduction of those Aristotelian ideas which we have already discussed. Formerly the dominant note of the more scientific side of Christian thought had been Platonic. To introduce Aristotelian conceptions in the thirteenth century meant just as great a re-orientation of ideas as to abolish them in the sixteenth. Yet this revolution was carried through and there was no persecution of the men who led it (the tales that Bacon had trouble with the Inquisition are probably false).

Thus the earlier history of the Church shows that it was not innately opposed to changes in scientific thought, and if in the sixteenth century parts of the Church acted temporarily as enemies of science, then some other factor than a purely religious one must have been involved.

The Fascist persecution of science to-day is clearly traceable to political causes. Was it perhaps the same in the sixteenth century? This was, after all, a period of struggles for freedom in the economic and political fields, struggles to create that democracy which we are to-day fighting to maintain. The economy of feudalism, which had served Europe so well in earlier times had by now completed its work. And within it was arising the new and progressive economy of capitalism, fighting for freedom from feudal restrictions, freedom to make and sell at a price determined by the market, freedom to trade without tolls and taxes, freedom to lend for interest and to employ wage-labour at the lowest price for which it could be bought, and freedom from government by a hereditary caste. That battle for freedom is the leading theme in the history of the sixteenth and seventeenth centuries and even later.



Reproduced from "History of Science, Technology and Philosophy in the XVIth and XVIIth Centuries," by H. Wolf, published by George Allen & Unwin Ltd., London

FIG. 2.—Portrait of Galileo

Was there any connexion between the battle for economic and political freedom and the battle for scientific freedom? Well, to begin with, it was the rising class of merchants and industrialists who had most use for science; they needed the results of science to work out the techniques of their new productive methods. They wanted, for example, a better astronomy to enable their mariners to find their positions at sea; and the whole growth of astronomy in the sixteenth and seventeenth centuries was closely connected with the vast expansion of sea commerce. In that way the growth of science was directly linked to the struggle against the feudal order for political and economic freedom. The scientist was adding economic strength to the rising classes and thereby helping to destroy feudalism.

But the followers of Copernicus were not persecuted because of technical contributions to the economy of capitalism. Galileo, in fact, was allowed to produce very important works of this nature while in prison. The persecution was concerned entirely with the wider cosmological and philosophical questions which we described above.

Was there then some connexion between these philosophical struggles and the battle between the dying feudalism and the growing democracy? Did the general conceptions of Copernicus in any way challenge the feudal regime?

A Challenge to Feudalism

The answer must surely be, Yes. The feudal system was trying to keep itself alive, although the whole trend of history, the whole economic movement of events was against it. To do so it must make the fullest use of ideological weapons. It must seek to maintain an ideology which was consonant with feudalism and not with capitalist democracy, an ideology which favoured stability and discouraged change.

For example, the survival of feudalism would be ensured if men could be made to believe that all truth was to be found in the works of certain ancient authorities. For, of course, feudalism had many centuries of authority to back it; capitalism and democracy had none. And it was precisely as feudalism became old and weak that its supporters came to rely more and more fanatically on authority.

Furthermore, the principle is one that must hold everywhere or nowhere, so that it had to be maintained in matters scientific as well as in matters political. To smash the belief in authority in one sphere—say in cosmology—was to threaten that belief in all spheres and so to endanger feudalism. That was one of the things that Copernicus did. If his ideas were true, many of Aristotle's must be false, and so authority was no longer to be relied upon—no more in social matters than in science.

That was the first point at which Copernicus challenged the ideology of feudalism.

But the philosophy of Aristotle meant more to feudal reaction than merely one example of authority. The whole teleological conception of the universe closely fitted the needs of feudalism. The idea that every *man*, as well as every *thing*, had his true and appointed place—the lord in his castle, the peasant at the plough—was ideally suited to the preservation of the old order against the ferment which was beginning to break down the old class divisions. If every man had his place in society as a part of the Great Purpose of the Universe, then what right had he to try to change that place? Sometimes, even, the Aristotelian conception of every element having its true place and trying continually to return there might be used by false analogy to demonstrate a similar structure in society. And at least the Aristotelian mode of thought made the mind more receptive for similar trains of thought in social affairs.

This general teleological mode of thought, so valuable to feudalism, was also challenged by the Copernican revolution—not consciously by Copernicus, but the implication was there, and his successors made the challenge more and more definite.

Again, the Aristotelian conception of an absolute barrier between the perfect celestial and the imperfect terrestrial spheres bore a close resemblance in form to the absolute barrier between the classes in an ideal and stable feudalism. That resemblance could also be used for political reaction. This barrier, too, Copernicus denied, for instance in relation to gravity, as we have seen already.

And lastly the conception that all change was an oscillation about an unchanging normal or a mere appearance behind which lay the unchanging eternal motions of the celestial spheres might be used to "prove" to men that there is no such thing as change, except in trivial matters, and so to discourage them from trying to make social changes. Copernicus issued no direct challenge here, yet the breaking down of the distinction between the heavenly and earthly spheres was a first step in that direction. And the development of a mechanical conception of the universe, the inevitable sequel to Copernicus' theory, abolished the idea of an unchanging appointed normal about which things oscillated and so at least permitted the idea of genuine novelty in the world.

Reproduced from Charles Singer's "A Short History of Science" (Clarendon Press).

FIG. 3.—The Universe according to Copernicus.

Though this diagram appears in Copernicus' book, it very much oversimplifies his system. It serves to stress the main point of the Copernican revolution—that the sun it is at the centre of the universe and the earth circles round it like another planet. But to represent the observed facts he had to retain the old device of th eepicycle, in which the planet moves in a circle whose centre moves on another circle.

In all these ways the Copernican theory threatened the ideology which was needed to preserve feudalism. And as the consequences of Copernicus, work were gradually developed, as the mechanical explanation of the universe began to replace the teleological, that threat became more and more serious.

Copernicus' Caution

Copernicus, of course, was no great social reformer (though he had many connexions with the social and economic affairs of Poland and wrote, for example, a treatise on currency reform, in which he anticipated Gresham's law). His fears of the consequences of publishing his astronomical work did not arise from a realization of the socio-ideological questions involved. He was conscious of the opposition of the orthodox, but not of

its social roots. On the other side, perhaps very few of those who maintained the orthodox cosmology and philosophy realized its relation to the preservation of feudalism. But, of course, the effectiveness with which an ideology is used to support a social system does not depend entirely on the conscious purpose of those who maintain the ideology. Nor does the persecution of those who challenge the ideology. It is sufficient if only a few men in positions of importance are conscious of the danger to the social system in which they are interested. Those few can whip up the petty self-esteem of the ignorant and bigoted into a fervour which will ensure the persecution of all who support the new views—and all the time most of the orthodox will remain unconscious of the reactionary political role they are playing and may well imagine that they are defending religious principles.

Copernicus, then, though he could not know the fundamentals involved, had very good reason to hesitate so long before taking the irrevocable step of publishing his theory to the world. And when he did publish it, he had very good reason to try to appease the enemy and to call to his side as much of the support of respectability as he could muster. Thus he was careful to dedicate his work to the Pope and to explain in his preface that he was persuaded to publish only by the urgent exhortations of a number of very eminent men, including a cardinal and a bishop. He claimed that his theory contained nothing contrary to the scriptures, though some might misinterpret it in that way. And for similar reasons of caution, when Rheticus published a little earlier a brief summary of the Copernican theory in his *Narratio Prima*, the name of the originator of the theory is carefully omitted.

In 1541, while he was yet in doubt as to the wisdom of publishing, Copernicus wrote to a Lutheran theologian, Ossiander, enquiring if it were possible to publish the theory without drawing upon himself the wrath of the orthodox. Ossiander replied:

> "For my part, I have always felt about hypotheses that they are not articles of faith, but bases of calculation, so that, even if they be false, it matters not so long as they exactly represent the phenomena of the motions. . . . It would therefore seem an excellent thing for you to touch a little on this point in the Preface. For you would thus render more complacent the Aristotelians and theologians whose contradiction you fear."

But this particular piece of appeasement was outside the range which Copernicus could tolerate. He believed his theory to represent physical fact, not a mere computing device, and though he is careful to avoid a needless declaration of war by saying this in so many words, yet the general form of *De Revolutionibus* makes it quite clear just where his beliefs stood. Ossiander, however, was in charge of the actual printing of the book and took the opportunity to insert, anonymously and without consulting the author, a preface along the lines recommended in his letter.

Actually *De Revolutionibus* did not immediately cause the storm that Copernicus had feared. In some circles its reception was very favourable. The German Rheinhold in 1551 calculated a new and revised set of astronomical tables based on Copernicus' theory, a considerable improvement on the tables with which Copernicus had concluded his book and a vast advance on the Alfonsine tables which had been standard since 1272. Improved tables were much in demand at this time to cope with the problems of a rapidly expanding navigation, and there is little doubt that these tables helped to spread the Copernican system among those who were associated in some way with sea-going commerce. So that it is natural that the theory should have been early welcomed in England, which was just entering upon a period of great expansion on the seas. From 1556 onwards Copernican astronomy received favourable mention among English writers—John Field in that year and others after him, including William Gilbert, who sought in his *De Magnete* (1600) to connect the new system with his theory of terrestrial magnetism.

For some years after its publication, where the teachings of *De Revolutionibus* were not accepted, at least they were not rejected with violence. Feudal reaction was not yet finding it necessary to take strong measures with those who upset its philosophy and cosmology, and probably few among the feudal ruling classes saw the full implications of the revolution of thought until it had advanced considerably farther.

Nevertheless, about the time when *De Revolutionibus* was published the weapons which were later to be used to attempt the suppression of free scientific thought were being prepared. It is unfortunate and it obscures the issue that these weapons should have been chiefly instruments of the Church; for the controversy was never really on a religious issue and the Church only came into it in so far as it had become politically associated with the mantenance of feudalism.

The Roman Inquisition was founded in 1542 to deal with questions of religious import, but in later years it was used only too often by unscrupulous ecclesiastical politicians. Eventually *De Revolutionibus* was placed on the Index of Prohibited Books, and in following years some supporters and extenders of the Copernican theory paid heavy penalties for their beliefs.

(*To be concluded*)

CORRESPONDENCE

Dear Sir.—In the article on the Sea as a Storehouse, by Dr. Armstrong, in the March issue, it is stated that gold was extracted from the sea during a month's working at one of the American bromine plants, but the cost of doing so was several times more than the value of the gold.

About 50 years ago, a company was formed in this country called, if I remember rightly, The St. Helen's Company, to operate (I believe), an electrolytic process for extracting gold from sea water.

A pilot plant was installed at Hayling Island and was operated for many years, but the costs were never quite brought below the value of the gold extracted, though they always hoped it would be. My father was financially interested in the concern, and I remember, as a schoolboy, visiting the plant with him, and I came across the share certificates among his papers after his death. I presume the company was eventually liquidated.—Yours faithfully, for THE BRITISH ALUMINIUM CO., LTD.,

Freeman Horn, *Intelligence Officer.*

Photo: V. L. Weiser.

FIG. 1—Podsol in profile, Vermont, U.S.A.

Mapping the Soil of Britain

G. W. ROBINSON, M.A., Sc.D.

ALTHOUGH the study of the soil has been actively prosecuted in Great Britain for nearly a century, it is only during comparatively recent years that attempts have been made to map the soil. Among the first systematic surveys was that of the soils of Dorset made in 1907 by D. A. Gilchrist and C. M. Luxmore. In this survey, as in the reports of W. Goodwin on the soils of Nottinghamshire, F. W. Foreman on the soils of Cambridgeshire, A. D. Hall and E. J. Russell on the soils of Kent, Surrey, and Sussex, and G. W. Robinson on the soils of Shropshire, the approach was mainly geological. It was assumed that each geological formation gave rise to characteristic soils, and the soils were, therefore, classed as Chalk soils, Gault soils, Old Red Sandstone soils, etc.

The inadequacy of the geological classification of soils became evident to the present writer when he began the study of North Welsh soils in 1912. Even if it is admitted that the geology determines the character of the soil, it is not the solid geology, but the superficial geology that is of critical importance. Even a small cover of glacial drift or hill wash that may be negligible to the geological surveyor is of the greatest significance to the soil surveyor.

Apart, however, from the complications consequent on the great complexity of surface geology, it became evident that not only the parent material, but also the mode of soil development, particularly the moisture conditions, determined the actual character of the resultant soil. Two soils may be derived from the same parent material, such as weathered rock, glacial drift, or alluvium, but may differ entirely because in the one case drainage is free and the other case impeded. Further complications may be introduced by erosion or accumulation.

An important part of the general renascence of soil science after the last war was the recognition of the significance of the soil profile as the unit of study. The impulse to this new direction of study came from the Russian school, notably from the work of V. V. Dokuchaiev and K. D. Glinka. Glinka's classical book, known to most western soil scientists in H. Stremme's German translation *Die Typen der Bodenbildung*, brought new life to soil science. Under the inspiration of Glinka's ideas, diffused in the early post-war years by C. F. Marbut (U.S.A.), G. Murgoci (Rumania), Peter Treitz (Hungary), and others, the study of the soil became something more than the improvization of methods to solve the day-to-day problems of practical agriculture, and emerged as an independent branch of natural science.

The new outlook consisted firstly in the recognition that the soil merited study from the standpoint and by the methods of pure science. The earlier soil studies, whatever they might have contributed to the solution of practical agricultural problems, had not greatly advanced our understanding of the fundamental constitution and classification of soils. Indeed, the lack of fundamental

knowledge of the nature of the soil had probably limited the usefulness of soil studies to agricultural practice.

Secondly, as the soil came to be studied for its own sake, there came the conception of a soil as a natural body and not as mere material. The unit of study became, instead of the soil sample dried and bottled in the laboratory, the soil profile viewed in the field. The conception of the soil profile is so fundamental in modern soil science that some effort must be made to understand it.

Soil Profile

If a deep pit or trench is dug in virgin soil under a cover of natural vegetation and the cutting viewed in vertical section it will be seen that the material is disposed into layers or horizons of varying character and thickness. These horizons constitute the soil profile, of which the lowest component is the geological parent material, which may be weathered rock, glacial drift, hill wash, or other unconsolidated deposit. The nature and succession of the soil horizons reflect the course of the soil-forming processes.

An example of a soil profile is seen in Fig. 1. It illustrates a soil developed under mainly coniferous forest in Vermont, U.S.A. At the surface is a mat of leaf litter with fine roots; this has bent over somewhat and partially obscured the next horizon of dark humic material, passing in turn to a dark humic sand. Below this is a sharp change to a light grey bleached sand with a loose, dusty structure. Passing down the profile, another change is seen below the bleached horizon. First there is a sandy horizon, about 2 inches thick, dark brown in colour and compacted by a humic cement. This is succeeded by a moderately compact rusty-brown sand, passing down to the parent material, a light brown loose sand. The transition from the rusty-brown horizon to the parent material is indicated in the illustration by a furrow drawn by the knife, seen resting against the face, which serves to show the scale of the profile.

The profile is an example of the so-called *podsol* profile developed under heath or coniferous forest in cool, humid climates. Similar profiles are to be found in this country. Owing to poverty of the soil in bases, humus and sesquioxides are leached from the upper horizons, the so-called *A* or *eluviated* horizons and deposited in the *B* or *illuvial* horizons.

Under conditions of restricted or impeded drainage, as in alluvial flats or low-lying boulder clay areas, a different type of profile develops, characterized by rusty-brown staining or mottling. The predominant ground colour is grey or even bluish-grey and is associated with the prevalence of anaerobic conditions consequent on waterlogging. In some cases the rust markings are confined to root channels.

Whilst the general tendency of profile development in Britain under conditions of free drainage is towards a podsolic type, good podsol profiles are not very common or widespread. When, as has been the case with most of Southern Britain, land comes under cultivation, the upper horizons of the profile becomes mixed together to form a uniform layer. In this way a *disturbed* profile results, in which only the lower horizons of the original profile survive as such. Centuries of cultivation may produce modifications even in the horizons untouched by cultivation and may alter the whole course of profile development. Maintenance in grassland may also induce profile changes.

Soil profiles may be *mature* or *immature*. Mature profiles occur where the soil forming processes have reached their full expression under virgin conditions, as in the soils of prairies and primitive forests. The soil profiles developed in recent alluvium or in blown sand are examples of soil still in the early stages of profile development. Immature profiles may be found in situations where surface erosion is heavy, as on steep slopes. With still heavier erosion, *truncated* profiles may result, in which the surface horizons are removed and the original sub-surface or B-horizon forms the present top soil.

The variety of soil profiles even in such a small country as our own is very great, resulting from the complexity of surface geology, topography, and hydrological conditions, on which are superimposed the modifications consequent on human interference either through cultivation, deforestation, or the effect of grazing animals. The aim of the soil surveyor is to show this variety graphically on a soil map.

Soil Series or Groups

The basic problem in soil survey is the classification of the observed varieties of soils into mappable categories. In this country, as in the United States and most countries of the British Empire where soil surveys exist, the most important unit is the *soil series*.

By a soil series is understood a group of soils similar in the character and arrangement of the horizons of the profile, and developed under similar conditions from one type of parent material. For particular purposes the soil series may be further sub-divided on the basis of texture into types. Series are named after the county or locality in which they are first recognized, for example the Salop series is thus called because it was first recognized and studied in that county. Salop heavy loam, Salop medium loam, and Salop silty loam are types within the series. Still further sub-division is possible by recognizing *phases*, e.g., sloping, steep, or rolling; stony, stoneless, or rocky. As a rule, however, there would only be a limited range of types and phases within a series. Any considerable variation would require the recognition of a separate series.

Six-inch-to-the-mile Ordnance Survey sheets are used as base maps. Uniformity is checked by auger borings. When the boundaries of a series or type have been delineated by auger borings, profile pits are opened up in typical localities and careful descriptions of the horizontal successions is made in each case. At the same time samples of each horizon are taken for laboratory examination.

Fig. 2 is an example of the kind of map produced by the soil surveyor. For simplicity, the details of the base map have been omitted, but in actual practice, the full topographical information given in the six-inch map forms an invaluable supplement to the purely soil data. The numbers refer to the soil series recognized in the area.

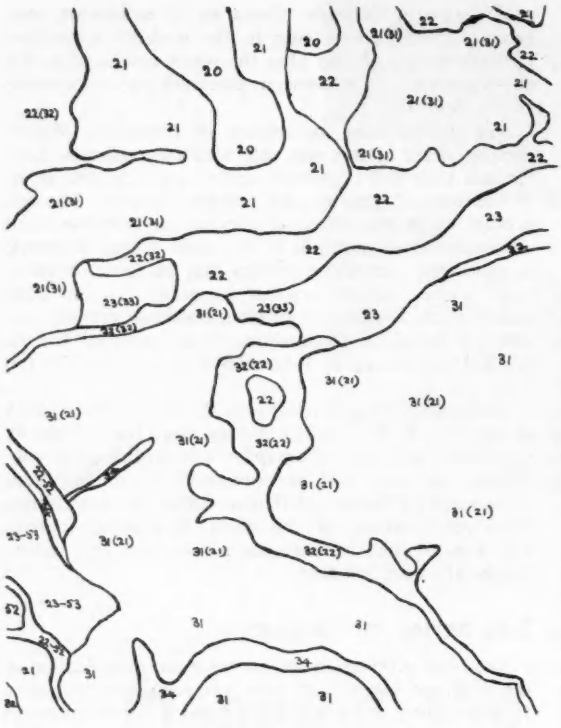


FIG. 7.—Specimen series map of a portion of Caernarvonshire.

These may be described briefly as follows:

20 *Bangor Series*. Thin light stony loams over weathered acid igneous rock.
21 *Arvon Series*. Light to medium stony loams derived under conditions of free drainage from drift (including boulder clay, fluvio-glacial sands and gravels, and hill-wash), composed of acid igneous rock material.
22 *Eivion Series*. Medium to heavy loams derived under conditions of impeded drainage from boulder clay composed of acid igneous rock material.
23 *Eivion Series* (improved). As 22 but improved by drainage.
31 *Penrhyn Series*. Similar to Arvon but derived from shaly drift.
32 *Cegin Series*. Similar to Eivion but derived from shaly boulder clay.
33 *Cegin Series* (improved). Similar to 32 but improved by drainage.
34 *Conway Series*. Medium to heavy loams derived from shaly alluvium. Drainage imperfect or impeded.
52 *Dinas Series*. Medium to heavy loams derived from mainly Carboniferous Limestone boulder clay,de calcified to 3 feet or more. Poor drainage.
53 *Dinas Series* (improved). As 52, but improved by drainage.

Where a second number is shown in brackets it indicates the presence of small islands or admixtures of the second series. For example 21 (31) indicates an area predominantly Arvon, but with small areas of Penrhyn or mixed Arvon-Penrhyn character. Two numbers separated by a hyphen represent a complex mixture, e.g. 23-53 represents a complex area of Eivion and Dinas soils in which neither series is markedly dominant. The delineation of boundaries between uniform series and mixed series is generally a matter of considerable difficulty in featureless drift areas, and it is frequently necessary to recognize complexes of two or more series.

Other Important Factors

If the fundamental classification is adequate and if mapping has been carefully executed, a soil map will provide an accurate inventory of one of our most important natural resources. It must be realized, however, that the agricultural and silvicultural capabilities of a given locality are not determined entirely by the soil conditions. Climate is of equal significance*. In this connexion it is important to note the significance of micro-climate, for within a uniform macro-climatic region small variations in rainfall or temperature conditions may have important consequences, particularly for the growth of horticultural crops. The soil survey, therefore, depicts only one group of factors and the ultimate object must be a synthesis leading to a classification and hence a map, showing utilization characteristics as governed by soil and climate, in other words a map of the soil-climate complex.

In addition to the physical factors of soil and climate, both the actual and feasible utilization of land are governed also by economic and sociological factors. Such is the complexity of the final pattern that it seems hardly possible to make any plan of the best possible use for a region because the non-physical factors are largely inconstant and unpredictable. Further, even use potentialities are affected by changes in agricultural or silvicultural technique. The soil-climate map may indicate certain possible uses for a site, but improvements in methods of cultivation or the discovery of new crop varieties may greatly enlarge these possibilities.

From what has been said, it is clear that a soil survey must be regarded as only one part of a wider survey and cannot give a final answer to the question: What is the best use to make of this or that piece of land? Yet soil survey can make a direct contribution to planning problems by furnishing the soil information for specific planning schemes. Indeed, no scheme for the planning and reconstruction of an area can be satisfactory unless the soil factors have been taken into account.

An important adjunct to the Survey in its widest sense is the accumulation of information about the agricultural or silvicultural properties of each soil-climate category. The soil surveyor himself in the course of his work will accumulate a considerable body of correlative agricultural data and will be able to assess the value of his soil classes for different types of utilization. Apart from this, general knowledge of soils and their relationships to plant growth will assist in forming judgements. To take an extreme case, it is part of the common experience of agriculturists that soils with imperfect drainage are subject to certain limitations in practical utilization. Existing knowledge, therefore, can provide much of the necessary interpretation of soil maps.

*It should be added that soil and climate are not independent variables. Gross differences in climate are reflected in soil characters and it would not, therefore, be possible to have the same soil occurring under two markedly different climates.

Our knowledge of soils and their relationships to crop growth is admittedly imperfect, and much more field experimental work is needed. Soil survey can make a definite contribution to the advancement of agricultural science by helping in the selection of experimental sites. Considerable advances have been made in experimental plot technique, but the most carefully designed field experiment will fail to achieve its object if uncertainty remains as to the applicability of the results obtained.

Systematic soil mapping by modern methods has only been in progress for about 10 years and the areas mapped are approximately as follows:

Reading province*	120,000 acres.
South-Eastern province	70,000 acres.
West Midland province	200,000 acres.
Bristol province	240,000 acres.
Wales	350,000 acres.

In addition, the counties of Denbigh, Flint, and part of Glamorgan have been covered in reconnaissance, and about 300,000 acres have been mapped in the same way in the Birmingham area.

Soil survey in Great Britain is at present in its preliminary stages. It has been in progress at a number of centres for nearly twenty years, but it is only within the past ten years that methods have been satisfactorily standardized. In 1939 the Ministry of Agriculture gave official recognition to the Soil Survey of England and Wales under the directorship of the present writer. At present there is a staff of six surveyors with two probationary surveyors.

With the present personnel the soil survey of the whole of England and Wales might occupy 40 or 50 years. The possibility of making more rapid reconnaissance surveys is now being explored with a view to obtaining a first approximation to a soil map of the whole country. Such a map might be of considerable value in future agricultural planning. Even a reconnaissance survey, however, would take considerable time. It is probable that the Soil Survey personnel will be most profitably employed in making *ad hoc* surveys of areas where planning is in prospect, as in the rural fringe of urban areas. It may be regretted that the soil map of Britain has not already been made but as in actual practice the methods of soil survey have been elaborated only during the past two decades, any surveys made before adequate technique was developed would have been of comparatively little value. It is to be hoped that progress will now be sustained and that as larger areas are covered the survey will grow in significance and usefulness.

*Agricultural advisory region.

The Night Sky in May

M. DAVIDSON D.Sc., F.R.A.S.

The Moon.—New moon occurs on May 4d. 09h. 43m. U.T., and full moon on May 19d. 21h. 13m. The following conjunctions will take place:

May				
5d. 22h.	Mercury in conjunction with moon,			
			Mercury	8°N.
6d. 15h.	Saturn	,,	Saturn	3°N.
7d. 18h.	Venus	,,	Venus	6°N.
9d. 21h.	Jupiter	,,	Jupiter	3°N.
28d. 10h.	Mars	,,	Mars	2°N.

Occultations.—The following occultations of stars brighter than magnitude 6 occur, the times referring to Greenwich:

May	6d.	9h. 01·1m.	α Tauri	D
	6d.	10h. 07·0m.	.. ..	R
	12d.	21h. 27·6m.	v Leo	D

(D and R mean disappearance and reappearance, respectively).

The Planets.—Mercury sets about 2 hours after the Sun at the beginning of the month. The planet, which attains its greatest eastern elongation on April 30, is stationary on May 12 and in inferior conjunction on May 23. Venus can be seen in the evenings: it sets at 23h. and 23h. 20m. approximately at the beginning and end of the month. Mars is a morning star and souths at 8h. in the middle of the month. Jupiter is still conspicuous in the early portion of the night and sets at midnight in the middle of the month. Saturn sets 1½ hours after the Sun in the middle of the month and is no longer conveniently placed for observation. (The times given are U.T., not Summer Time, and the latitude of Greenwich is assumed.)

Meteors.—The η Aquarids can be seen in the morning hours from May 1 to 6, but the shower is very feeble and at the most probably only a few meteors will be seen. These meteors are the débris of Halley's Comet, the earth intersecting this débris, which is spread out along the orbit of the comet, in the early part of May each year.

The Scientific Control of Milk

[CONCLUSION]

J. G. DAVIS, D.Sc., Ph.D.
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THE following questions must be answered before discussing any testing any bacteriological control scheme:

(1) what property of milk do we wish to measure?
(2) which is the best test?
(3) how many producers must be tested and how often?

A peculiar point about the bacteriological testing of milk is the multiplicity of aspects—do we wish to measure bacterial numbers only, *or* methods of production, *or* of production and handling, *or* keeping quality and if so under what conditions?

The various tests measure different aspects as follows:

Test	*Factors measured*
Plate count	Living bacteria
Microscopic count	Living and dead bacteria
Methylene blue	Bacterial activity (and so keeping quality).
Resazurin	Bacterial activity.*

As the resazurin is 5 or 6 times quicker than the methylene blue test, it has a considerable claim to be considered the best practical test for the routine grading of milk. Certainly the resazurin and methylene blue tests are the only two possible for large-scale work. In the writer's opinion it is not fundamentally important which test is used—all tests are adequate to classify producers in A, B or C categories. The important thing is to ensure that *all* producers are tested regularly, say once a fortnight. Hitherto about 10% have been tested by an expensive test and advisory work rather concentrated on the best 10 or 20%. This is patently wrong. All producers should be tested by a simple, inexpensive test, and advisory work concentrated on the bottom 20%.

National Milk Testing and Advisory Scheme

This has been evolved by the Ministry of Agriculture in 1942 and may be considered to have been in working at the larger creameries since 1st June, 1942. This scheme at present has two distinct objects for which two distinct tests are used, and it is necessary that this should be clearly understood, as much confusion has arisen on this point.

(1). In order to prevent very dirty (high count) milk from being accepted at creameries and mixed in with the bulk, a standard *platform rejection test* is applied to all milks which are suspect for any reason, e.g. abnormal smell. The test used is the *rapid* (10 *min.*) *resazurin test*, and the universal adoption of this test undoubtedly marks a great step forward in this country. Previously each buyer used his own test (usually the titratable acidity test which is not reliable for producers' milks) and set his own standards. This caused much heartburning in some producers, but there is now no longer any grounds for complaints that unfair discrimination is exercised. In using this test, milk reaching disc 3½ down to 1 is classified as SALVAGE milk (Table VIII) and will ultimately be utilized by the Ministry of Food in some form of manufacture. Milk which completely decolourizes the pink resorufin (disc 0) or partially reduces it (disc ½) will be returned to the farmer and termed REJECTED milk (Table VIII). In this way there will be no market for very bad milk and only a salvage price, e.g. 6d. gallon, for unsatisfactory milk. There can be little doubt that this scheme, commonly abbreviated to NMTAS, will be a great boon to the industry and replace the previous chaos by an orderly procedure.

*A considerable amount of udder disease in the herd may result in a slight lowering of the bacterial grading.

TABLE VIII

SYNOPSIS OF TESTING SCHEMES AND GRADES

Grade.	*Quality.*	*Test.*	*Standard.*	*Approx. Plate Count.**	*Action taken.*
Routine grading tests.					
A (NMTAS)	Good	St. resazurin[1]	Disc No. 6–4	<200,000	—
Accredited (Min. Health) ..	,,	Meth. blue[2]	>4½ hours May to Oct. >5½ hours Nov. to Apr.	,,	—
B (NMTAS)	Indifferent	St. resazurin[1]	Disc No. 3½–1	200,000 to 10,000,000	—
C (NMTAS)	Poor	St. resazurin[1]	Disc No. ½ or 0	>10,000,000	—
Quick platform tests					
MARKET	Acceptable	Rapid (10 min.) resazurin[3]	Disc No. 6–4	<15,000,000	Accepted
SALVAGE	Poor	,,	Disc No. 3½–1	15,000,000 to 200,000,000	Utilized as salvage
REJECTED	Unfit for human consumption	,,	Disc No. ½ or 0	>200,000,000	Returned to farmer

* This value varies over a wide range and the figures quoted are intended to serve only as a guide.
[1]Test carried out at 24 hours. [2] Test carried out at 12 or 18 hours. [3] Test carried out on arrival at creamery.

(2). In order to assess the bacterial quality of the milk of all producers, and to permit the organisation of a really efficient system of educational and advisory work for backward producers, a standard *routine grading test* has been instituted and will ultimately be applied to all producers' milks, including producer-retailers. The test provisionally adopted is a resazurin test in which the time of incubation is varied according to the mean atmospheric temperature during the 24 hours following production. All milks are tested after holding for 24 hours at atmospheric temperature. The ideal system would be to sample on the farm, hold for 24 hours at 18°C and then test by a 1 hour resazurin test, but unfortunately farm sampling is impracticable. The tentative times of incubation and gradings are given in Table IX.

TABLE IX

TIMES OF INCUBATION FOR THE STANDARD RESAZURIN TEST (NMTAS)

*Mean atmospheric temperature**	*Time of incubation at 37°C.*
40°F. and under	120 mins.
41—50°F.	90 mins.
51—60°F.	60 mins.
61—65°F.	30 mins.
Over 65°F.	15 mins.

* This is defined as the mean of the minimum night and maximum day temperatures during the 24 hours following production.

In the opinion of the writer the only satisfactory method of tackling the 5% to 10% really bad producers will be a system of quality payment in which the price paid per gallon will vary according to the chemical and bacteriological quality of the milk. We have suggested the following formula as the basis for such a system:

$$\text{Price per gallon} = \text{Basic index} \times \text{T.S.} \times \frac{14 + R}{20}$$

Where T.S. = total solids %
and R = resazurin disc number in routine grading test (maximum 6, minimum 0).

Special Problems of Pasteurised Milk

Pasteurised milk is a very topical subject now in view of the renewed interest in the proposal compulsorily to pasteurise all milk. The medical profession has for long strongly urged this course, and many farmers and dairymen have equally strongly opposed compulsion. We cannot here discuss the pros and cons of the case, but it should be remembered that only persons trained in biochemistry and bacteriology and experienced in the milk industry can voice a competent opinion on this thorny subject. As an impartial observer, we may say that the case for pasteurisation, at least of all non-T.T. supplies, is overwhelming. The only serious objection is that pasteurisation (heating to 145°F or 62·8°C for 30 minutes) may destroy some vital property of the milk. This view is now discredited in all serious scientific circles. The effects of pasteurisation, sterilisation (*c.* 220°F for 20 to 30 minutes), evaporation and drying on the more important constituents of milk are shown in Table X. Summarising these data we may say that pasteurisation has no significant effect on the nutritional value of milk.

Methods of Pasteurising Milk

The objects of pasteurising milk are to kill bacteria—pathogens so that the milk can no longer be a source of disease, and non-pathogens so that the "life" or keeping quality of the milk is improved. Both aspects are of the greatest importance and large cities could not be supplied with milk in summer without extensive pasteurisation. The most heat-resistant pathogen in milk is *Mycotuberculosis*, so that, if this organism is destroyed, it is assumed that all other pathogens have been destroyed also. The time-temperature conditions of pasteurisation are based upon this, and as it is found that most T.B. are killed in 10 minutes at 145°F and all in 20 minutes, the official conditions are 30 minutes at 145°F. If the temperature is raised, a shorter holding time can be used, e.g. at 162°F (71·1°C) an exposure of 15 seconds effects the same treatment as 30 minutes at 145°F. (cf. Fig. 13). There are two main methods of pasteurising milk:

(1) the *holder method* of 30 minutes at 145°F.
(2) the *high temperature—short time* (HT-ST) method of 15 seconds (nominal) at 162-164°F.

The first is the classical method in almost universal use in this country until recently. It is the most fool-proof. The second is a continuous process and has the advantage of being possible with a much more compact apparatus. The principle of the method is illustrated in Fig. 14.

An interesting modification of the holder method is the *in-bottle* method in which the bottle is used as the holder (Fig. 15). In ordinary commercial pasteurisation the treated milk is inevitably re-contaminated before

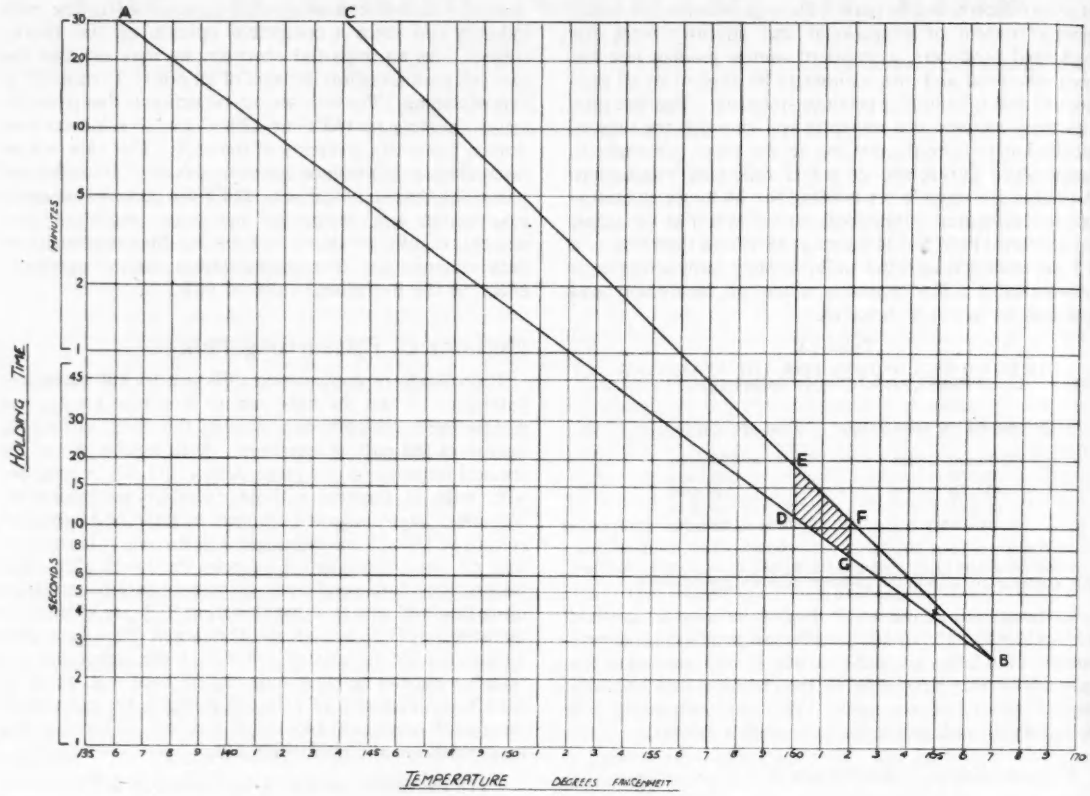
TABLE X

COMPARISON OF NUTRITIONAL EFFECTS OF VARIOUS HEAT TREATMENTS AND PROCESSING OF MILK

(*Change produced in relation to raw milk*)

Type of treatment.	*Vitamin A.*	*Carotene.*	*Vitamin B_1*	*Vitamin B_2*	*Vitamin C.*	*Biological value of proteins.*	*Digestibility of proteins.*
Pasteurisation	None	None	10%	None	Loss 20%	None	None
Spray-drying	None	None	10%	None	Loss 20%	Possibly small lowering	Probably none
Roller-drying	None	None	*c.*15%	None	Loss 30%	Possibly small lowering	Probably none
Sterilisation	None	Negligible	Loss 30%	None	Loss 50%	6% decrease	None
Evaporation (unsweetened)	None	None	Loss 40%	None	Loss 60%	Probably slightly lower than that of roller- and spray-dried milk	Slightly lower than that of roller and spray-dried milk

Kon (*Nature*, 1941, **148**, 607).



Courtesy of The Aluminium Plant & Vessel Co., Ltd.

FIG. 13.—At all combinations of time and temperature which fall within the triangle *ABC* Tubercle bacillus is destroyed whereas cream line is unimpaired. At points to the right of *BC* cream line is damaged. At points to the left of *AB* Tubercle bacillus survives. Note how the margin diminishes as *B* is approached. The area *DEFG* marks the combinations of time and temperature generally accepted for the High-Temperature Short-Time Process.

reaching the consumer. The *in-bottle* method avoids this. In spite of technical objections to this process, there is no doubt about the superior keeping qualities of such milk. Bacteriologically it is the ideal method and it will be interesting to see if the process is generally taken up after the war.

Tests for Pasteurised Milk

Tests for efficiency of pasteurisation are usually based upon the fact that certain enzymes are completely or almost destroyed by the correct time-temperature conditions. The one in general use now is the *phosphatase test* devised by Kay and Graham at Reading. Slightly more severe heat treatment is required to destroy phosphatase than to kill T.B., so that a negative *phosphatase test* is considered satisfactory evidence for the proper pasteurisation of the milk. If the milk is heated too drastically the "creaming" power is diminished, and this is generally avoided. Fig. 13 shows the time-temperature relationships which destroy T.B. and which begin to damage the cream line.

The keeping quality of pasteurised milk is best measured by a dye reduction test at low temperatures, e.g. 15·5° or 18°C. It is customary to hold the sample at room temperature for 24 hours before testing.

A Scientific Policy for Milk

It is highly desirable that all authorities concerned should get together and agree on a sound scientifically-based policy for milk control. The writer suggests the following as essential points in such a control scheme:

(1) compulsory pasteurisation of all milk other than high-grade T.T. (tubercle-free) milk.

(2) proper control of all dairies and creameries handling or pasteurising milk by *adequately trained personnel.*

(3) regular testing of all supplies, both raw and pasteurised.

(4) quality payment.

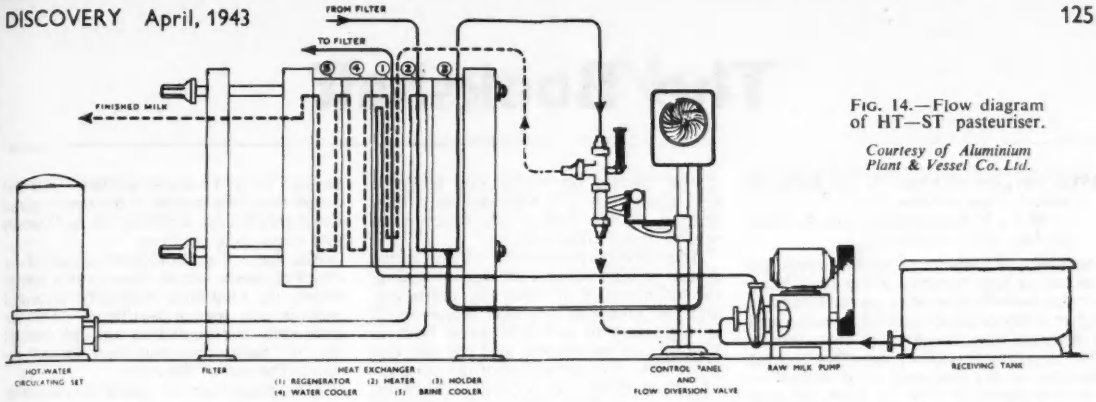


FIG. 14.—Flow diagram of HT—ST pasteuriser.

Courtesy of Aluminium Plant & Vessel Co. Ltd.

The milk is pumped from the tip tank by the centrifugal pump into the regenerative section of the Heat Exchanger marked (1), where it is pre-heated for efficient filtration and then returns for final heating in section (2) of the machine. At the carefully controlled temperature of 162°F. it enters the holder (3) at the inlet of which is located the bulb of the combined temperature recorder and Flow Diversion Valve, together with a visual check thermometer.

After holding, the milk passes to the Flow Diversion Valve and then back to the regenerator (1), water section (4) and brine section (5) for cooling.

The pipe line through which it flows is arranged at such a height that should the Flow Diversion Valve be automatically called into operation all the milk must pass downwards into the suction side of the raw milk pump, and none can pass forward.

The whole mechanism remains in this condition until the necessary measures have been taken to correct the fault and until the temperature regains the figure of 162°F. when the operator is able to lift the weight, re-set the pin by hand and the milk passes again to the cooler.

It is known that such a temperature system has a certain time lag which has in fact been very carefully measured and tested in our works.

It is of the order of 2-5 seconds according to conditions, so that, as the holding time through the holder is 15 seconds, there is a factor of safety of at least 3 : 1 to ensure that no under-heated milk can possibly pass through to the cooler. Similarly an automatic arrangement is provided which positively prevents the operator re-setting the diversion valve until the temperature has been re-established for at least 20 seconds, thus making quite certain again that no under-heated milk can pass forward.

The thermograph gives the normal record of time-temperature treatment.

Courtesy of A. G. Enoch, Esq.

FIG. 15.—Duplex Bottle Pasteurising, Cooling and Chilling Machine.

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The Bookshelf

Prism and Lens Making: A Text Book for Optical Glassworkers, by F. TWYMAN, F.Inst.P., F.R.S. (Adam Hilger, Ltd., London, 1942, p. 184, 15*s*.)

ALMOST all amateur astronomers are sooner or later tempted to try their hand at the manufacture of a concave mirror. After many hours of patient grinding and polishing, they are usually dismayed to find that their first effort has either become defaced with a fine crop of scratches, or that its figure is very far from the true sphere which should have been produced according to the text-book.

Figuring to a paraboloid seems like a distant dream, and the possibility of going further and attempting to make a prism or a lens is beyond contemplation.

To these and others who wish to enter the mysteries of optical work, this volume of wisdom accumulated over many years by the managing director of what is probably the best known British firm of manufacturers of precision optical instruments will come as a real blessing.

The book is a judicious combination of the theoretical and the eminently practical, and it contemplates the manufacture not only of single components, but also of batches with the aid of machines.

The claim made in the preface that "these methods and machines will enable even an unskilled worker, after a short period of training under competent supervision, to produce work of first quality as far as definition and accuracy of angle are concerned" seems fully justified. Thus the book is likely to be of very considerable value in this time of war, when it has become necessary to undertake an enormous expansion of our production of optical instruments.

The book begins with an historical summary of the development of optical manufacture, and a theoretical discussion of the nature of the grinding and polishing processes. The reader is next initiated into the mysteries of the technical details of abrasives, and of the composition and construction of polishing laps. Special attention is devoted to the elimination of the arch enemy—dust.

These principles are then discussed in relation to their applications to the manufacture of lenses and prisms. It is difficult to summarize, but an idea of the thoroughness of the work may be gained from the way in which the topic of the balsaming of compound prisms is discussed. Several sections treat in detail of the relative merits of different grades of balsam, and even such details as the names of firms from which they may be purchased, and the technique for avoiding dermatitis due to fluids used for the removal of Canada balsam, are not forgotten.

As may be expected in a work associated with the name of Hilger, the subject of the testing of optical work is treated with especial thoroughness and care. A large number of testing techniques are described and there are very full references.

The chapter on microscope lenses is very short, but it is followed by a final chapter on the testing and selection of optical glass before working.

There are five appendices, which include details of light sources for optical testing, the technique of silvering and sputtering, and the annealing of glass. Appendix D is a glossary of technical terms both in English and in French, and the last one gives tables for the testing of the parallelism by a variety of methods. There are two comprehensive indices. D.S.E.

Insect Pests in Stored Products. By H. HAYHURST, F.I.C., A.M.I. Chem. E. Photographs by Harry Britten, F.R.E.S., with a Foreword by Sir Harold Hartley, C.B.E., F.R.S., and a Preface by T. W. Jones, B.Sc., 2nd edition. $8\frac{3}{4} + 5\frac{1}{2}$ in., xii + 108 pp., 55 pls. (Chapman & Hall, Ltd., London, 1942. Price 15*s*.)

THE huge reserves of good materials which modern civilization demands create a number of very special problems for producers, manufacturers, shipping agents, railway companies, warehousemen, wholesalers and retailers. The fact that the path is long between producer and consumer implies that months, or even years, may elapse before the fruits of the harvest reach the table. During this prolonged interval stored products are constantly exposed to the danger of infestation by insect pests and the damage done runs into many millions of pounds annually. The people who have to handle these stored products are not entomologists and cannot be expected to know offhand the difference between a cockroach and a beetle, yet when faced with an outbreak they require to know the name of the pest and the treatment necessary to bring it under control.

This book is an attempt to meet such a demand, a demand so large that a second edition has been called for within two years of publication of the first. The reader will naturally rely largely upon the photographic illustrations for his determinations, some of these—notably those of moths—are good, but others give little more than an indication of the shape of the insects figured, all detail being lost in the general soot and whitewash effect. Indeed it is very doubtful if the photograph is the correct medium for the proper portrayal of solid thick subjects like beetles, and the most life-like results seem to be achieved by pen-and-ink artists. In any case the photographs are very badly arranged with much waste space, and although the magnification is indicated it would have been much better to have recorded the actual size of the insects by means of an index line against the enlarged figures.

Having made a provisional identification the user will endeavour to verify his findings from the text, but here again he will meet trouble as the descriptions are in many instances so short and so inanely similar as to be quite useless. For example the given species of the beetle genus *Cryptophagus* are all stated to be "brown and about 2-2½ ins. long".

The lists of commodities attacked by specified pests are in some cases extraordinarily long and curiously arranged without due regard to affinity. This information is repeated as an alphabetical list of "Substances and their Pests" towards the end of the book.

The discussion of control measures occupies only about six pages and although some useful hints are given, this should have been a major feature of the book and is capable of very considerable expansion.

It must not be imagined that all insects associated with stored materials are necessarily harmful, some of them may be parasites or predators on the species which actually do the damage, a list of such insects is given.

The volume closes with a lengthy biography, but its titles frequently differ from those under which the papers originally appeared, and specific reference to the various entries in it is lacking in the text.

To sum up, we do not believe that the public will remain satisfied with this work for long: it contains too many examples of wasted opportunities. B.M.H.

Free Will and Determinism, by M. DAVIDSON, D.Sc., with a Foreword by Sir Richard Gregory. (Watts & Co., London, 1942, xv + 203. 10*s*. 6*d*.) (A).

The Free Will Controversy, by M. DAVIDSON, D.Sc. (Watts & Co., London, 1942, ix + 118. 7*s*. 6*d*.) (B).

THE Preface to the first book (A) states that the outlook of the theologian has little in common with that of the scientist. Dr. Davidson, astronomer and clergyman, sides with the scientist, repudiates supernaturalism and considers theology a waning force in his second book (B, pp. 5 and 109). Even on free will, according to him, the final word will be spoken by the biologist (A, p. 104), as on biological phenomena by the physicist (A. 141).

The first half of (A) is entirely devoted to the theories of Jeans and Eddington and their critics Cohen, Levy, Dingle and Joad. It has become popular to deduce indeterminism from atomic physics. The impossibility, by present methods, to predict the moves of an electron is used—or abused—"to escape from a deterministic scheme", "to save human free will from disaster", as Gregory puts it. But Davidson judges—correctly, I think—that "recent physical research has left the problem simply where it was" (A, pp. 13, 48, 187).

The second half of (A) deals with the mechanistic view of life in its various aspects, with "absolute standards", and religious experience. Davidson considers Truth (and I suspect also Ugliness and Evil) as "absolute", but Beauty and

(*Continued on page iv of the Supplement.*)

Far and Near

Electron Microscopes on Lease-Lend

SEVEN electron microscopes, as mentioned in this month's note book, have arrived in this country from America under Lease-Lend. This fact was revealed by Sir Lawrence Bragg in a lecture at the Royal Institution on March 12. Probably the most interesting photograph taken with this instrument and exhibited by Sir Lawrence was one which showed a germ, *Escherichia coli*, surrounded by many small bodies, which, it is suggested, may be the bacteriophage organism that attacks and causes disintegration of bacteria. Until now the normal bacteriophage has been beyond the range of ordinary microscopes. Its size can be judged from the fact that it is filter-passing. Just before the process of binary fission is completed the organism would be twice the size of one individual, and it has been claimed that at this stage the bacteriophage is visible under the oil immersion objective. The electron microscope, with a resolving limit of 15 Angstroms, is capable of settling this and other ultra-microscopic doubts.

Sir Lawrence explained the difficulties which arise through the object for examination having to be mounted on a thin strip of cellophane-like material, and from the necessity of obtaining a vacuum in the tube of the microscope in order to project the electron stream.

Research in the Colonies

THE latest report on the operation of the Colonial Development and Welfare Act, which was passed in July 1940, gives encouraging details about the financing of research projects in the Colonies. The report states that the expenditure authorized by the Act for the purposes of schemes for promoting research or inquiry is limited to £500,000 in any financial year, while that provision is not subject to any limitation as regards its duration.

Since October 1942 grants for colonial development and welfare have totalled £2,032,399, while the total of grants for research amounts to £57,158. Examples of research projects financed under the Act are sisal research at the Sisal Research Station in Tanganyika (£10,000) and research into the diseases which afflict the cocoa plant on the Gold Coast (£17,000). Under development and welfare schemes large sums of money are being spent on such problems as the control of locusts, rinderpest, malaria, yellow fever, leaf spot disease of bananas, yaws, and ticks.

The report envisages that the Act will be implemented on a more ambitious scale when the war ends. The individual schemes given in the report are intended to form parts of more comprehensive programmes, which have not yet been finally completed.

A research committee under the chairmanship of Lord Hailey has been set up to advise the Colonial Secretary in regard to proposals for assistance for research and inquiry under the Act, and secondly to advise upon and co-ordinate the whole range of research in Colonial studies irrespective of the provenance of funds.

Since the report was prepared the Colonial Products Research Council, an executive body under the chairmanship of Lord Hankey, has been appointed to consider how by the application of research greater use can be made of colonial raw materials. The council's director of research is Professor J. L. Simonsen, lately of University College, North Wales.

The production of food yeast in Jamaica, as reported in the last issue of *Discovery*, is an example of the type of research and development which can be sponsored under the Act.

New Air Research Chief

DR. B. MELVILL JONES, professor of aeronautics at Cambridge University, has been appointed chairman of the Aeronautical Research Committee in succession to Sir Henry Tizard, who has resigned from the post which he has held for ten years.

Professor Jones was knighted in the New Year's Honours List last year "for services to aircraft development". As long ago as 1910 he was engaged on aeronautical research at the National Physical Laboratory. In the last war he served as a pilot.

Sir Henry Tizard was one of the original "boys in the back room" so far as aeronautical research was concerned in the field of aeronautical research. During the last war he too was a pilot, but later was transferred to research, becoming assistant controller of air research. Some months before this war started he was seconded from his rectorship at the Imperial College of Science and Technology to take charge of R.A.F. research. In the summer of 1941 he was appointed an additional member of the Air Council, and in this capacity and as a member of the Aircraft Supply Council he has had special responsibility for studying and advising on scientific and technical policy. Sir Henry has also been chairman of the Air Ministry's committee, set up in 1935 to survey the science of air defence. It is this committee which has been aptly described as "the midwife of radio-location". He recently succeeded the late Dr. G. S. Gordon as President of Magdalen College, Oxford.

Eminent American Scientist in Britain

IT is reported that Dr. Irving Langmuir, the President of the American Association for the Advancement of Science, is visiting London on a scientific mission.

Dr. Langmuir, who won the Nobel Prize for chemistry in 1932, last visited this country in 1938, when he was the first American to deliver a Pilgrim Trust Lecture before the Royal Society, of which is a foreign member. On that occasion he gave a fascinating account of his views on the structure of protein films.

Industrial Health Committee

To ensure that the results of industrial health research are applied as speedily as possible the Minister of Labour has appointed an Industrial Health Advisory Committee. Among its members are Prof. A. W. Ellis, of the Medical Research Council and Regius Professor of Medicine at Oxford, Dr. J. Fox (Government Chemist), Prof. J. A. Ryle (Professor of Social Medicine, Nuffield College), and Dr. D. L. Smith (Superintendent of the Engineering Department of the National Physical Laboratory).

Announcing the committee's formation, Mr. Bevin said there was room for a great expansion of facilities for the teaching of industrial medicine and hygiene, and he hoped that a knowledge of factory hygiene would become one of the qualifications for management.

Research on Camouflage Detection

THE armies of all the belligerent nations have been promoting research to find means of penetrating military camouflage. It is reported that the U.S. Army Air Force experimental laboratories at Wright Field, Dayton, have now perfected aerial cameras using Technicolor film which go a long way towards rendering camouflage useless. Another camera technique which has been tried involves the use of infra-red film; but by the use of special camouflage paints the camoufleurs have been able to produce camouflage effects which defy detection by infra-red film.

New Textile from Indian Weed

AN Indian scientist, Dr. Bhatnagar, has devised a process whereby a common Indian weed known as *ak* can be used in the production of a new textile which, it is claimed, "possesses the qualities of wool". Ak fibres are too short for spinning by themselves, but it can be spun into cloth when mixed with cotton.

A Disease-Resistant Banana from Jamaica

BANANA growing in the West Indies has been seriously menaced in recent years by the attacks of fungoid diseases. From Jamaica last month (March) comes the announcement that a type of banana has been perfected which is immune from the diseases. The new fruit, which is the result of work by Mr. J. B. Sutherland, is now going through cold storage and shipping tests prior to its cultivation on a large scale.

Perennial Wheat

The perennial wheat created a great deal of interest when it was first bred by the Russian academician Tsitsin by crossing wheat with couch grass. The latest variety of this cereal is claimed to be immune both to drought and fungus diseases, and yields within two years of sowing a crop of about 40 bushels to the acre.

Plastic contact lenses for correcting eyesight

THE idea of contact lenses which enabled Squadron-Leader G. B. Warnes recently to win the D.F.C. in a sweep over France dates back to 1827, when Sir John Herschel suggested that the human eye might be protected from a diseased eyelid by a glass lens covering the eyeball. For some years now glass lenses have been manufactured to fit the eyeball as Herschel anticipated, and they are used to correct sight without a spectacle frame being used. But contact lenses of glass are comparatively costly, and there is always the danger that they may be fractured. Thanks to the work of American scientists, some 5,000 people in the States are now wearing plastic contact lenses, which are comparatively cheap and do not splinter if knocked.

The fitting of a contact lens begins with the optician examining the eye and making his prescription for sight correction in the ordinary way. Then a local anæsthetic is given to the eye. A hydro-colloidal plastic composition at 118° F. is poured into a casting shell, cooled to 107° F. and the whole quickly inverted over the eyeball, the eyelids being pressed away at the same time. When the plastic material solidifies, it is removed from the eye and provides a negative impression of the eyeball. Using the mould so obtained a positive is cast on which transparent material is shaped to fit the eye and make the lens, which is then ground on its external surface to the correct optical requirements.

Many people find they can wear the new lenses for twelve hours at a stretch, although it is not advisable to sleep with them on. The lenses are very durable, lasting for as long as ten years. When their manufacture has been expanded, contact lenses will allow a multitude of people to do work and play games where the wearing of spectacles would be dangerous, as in the case of Squadron-Leader Warnes.

Immortal tissue

TISSUE from a chicken's heart originally propagated by Dr Alexis Carrel in his classic tissue culture experiments which won him the Nobel Prize is still alive after 31 years in a flask at the Lederle Laboratories, New York.

Three Colds a Year

IN a London lecture on March 16, Dr. Robert Cruickshank of the L.C.C. Group Laboratory said the average Englishman has three colds a year. If a workman was off for only one day per cold the total loss to the community each year amounted to 40,000,000 working days. Of the possibility of a recurrence of an epidemic of influenza on the 1918 scale, he said that war itself did not bring about flu epidemics, which tended to occur and reach their highest peaks every four years. "We have had no real attacks since 1937 and therefore must expect our immunity to influenza to have been reduced to a low level. To stave off a possible epidemic we can apparently control a small outbreak by prophylactic vaccination, but the only possible means of checking its spread is by a strict system of quarantine."

Killing Weeds by Sulphuric Acid

THE current issue (March) of the *Journal of the Ministry of Agriculture* gives interesting details about the use of sulphuric acid as a spray to control weeds. The author, Mr. G. E. Blackman of the Imperial College of Science, says the use of sulphuric acid is not new, first being tried in France in 1898. Many experiments on the control of the annual weeds in cereal crops were carried out in England during 1932-35, and since then a large acreage of corn has been sprayed to kill yellow charlock and other weeds.

As a result of more recent experiments it is concluded that acid spraying for weed destruction in horticultural crops such as onions can be undertaken by two main methods of application. The first is concerned with crops which are sown early in the spring when seeds germinate slowly, and also with other seeds which even in warmer weather germinate slowly. In both cases many weeds germinate before the crop. As a result, when the seedlings do appear above ground, they have to compete with weeds already well established. Sulphuric acid spraying, it is found, does not disturb the soil surface and its action is confined to the surface layer; acidification is temporary and localized in the top one-tenth of an inch. This pre-emergence spraying can be applied to parsnips, onions, leeks in the seed-bed, and spring-sown carrots, and root crops with slow-germinating seeds such as mangolds and beetroot.

Spraying must not be delayed until the crop has shown itself above ground; otherwise both crop and weeds will be killed. No weed seedlings can withstand a mixture of 13 gallons of commercial sulphuric acid and 87 gallons of water. One pint of a liquid wetting agent of the sulphonated oil type is added to this mixture. The method of control is at least 90% efficient. Two common weeds, Stinking Mayweed and the Scentless Mayweed, require a stronger concentration of acid, however. The acid solution is applied at the rate of 100-150 gallons per acre according to the type of spray used.

A second and more specialized spray technique has been worked out for onions. It depends upon the fact that once the onion seedlings have straightened out their leaves are waxy and upright, and the basal growing points are concealed, so that the plants are resistant to sulphuric acid so long as the concentration is not more than 10%. Most weeds on the other hand are killed because their shoots, not being waxy, catch the spray, and their growing points are exposed to the acid. The method can be compared to the use of ammonium sulphate in lawn sand, which kills the broad-leaved weeds but leaves the grasses unharmed. This type of weed control in onions is explained in the Ministry of Agriculture's Advisory Leaflet No. 109.

Chemical Control of Water Weeds

IN America a chemical method is being used to clear the rivers and lakes of a pernicious water weed, the water hyacinth. Dr. H. A. A. Hirsch has found that sodium pentachlorphenate is effective for the purpose in a dilution as great as 80 parts in 1,000,000.

The New Fellows of the Royal Society

LAST month (March) the Royal Society elected the following Fellows:

SIR SHANTI SWARUPA BHATNAGAR, director of Scientific and Industrial Research, India; aged 48.

PROF. PATRICK ALFRED BUXTON, director of the entomology department, London School of Tropical Hygiene; entomologist to the Government of Palestine 1921-23; led scientific expedition to Samoa 1923-25; at present imparts knowledge of disease-bearing insects to medical officers of the Fighting Forces; aged 50.

PROF. IVAN DE BURGH DALY, professor of physiology at Edinburgh since 1933; aged 50.

SIR JOHN AUGUSTINE EDGELL, hydrographer of the Royal Navy; awarded O.B.E. for services while in command of surveying ships in the last war; aged 62.

DR. ARTHUR JAMES EWINS, director of research of May & Baker, Ltd.; his research team was responsible for discovering M. and B. 693 and other chemotherapeutic agents; aged 61.

DR. JOHN JACOB FOX, Government Chemist, born 1874; member of the Colonial Products Research Council recently set up.

PROF. ALEXANDER FLEMING, professor of bacteriology, St. Mary's Hospital; discovered penicillin.

PROF. WILLIAM MICHAEL HERBERT GREAVES, Astronomer Royal of Scotland and Professor of Astronomy at Edinburgh University since 1938; aged 45.

GUY ELLCOCK PILGRIM, formerly superintendent of the Geological Survey of India; aged 68;

DR. REGINALD EDWARD STRADLING, chief adviser of the Research and Experiments Department of Ministry of Home Security.

DR. CHARLES SYKES, superintendent of the Metallurgy Dept. of the National Physical Laboratory.

PROF. JOHN LIGHTON SYNGE, professor of applied mathematics Toronto University; aged 46.

PROF. GEORGE FREDERICK JAMES TEMPLE, professor of mathematics at King's College, London, since 1932; aged 41.

PROF. SOLLY ZUCKERMAN, professor of anatomy at Birmingham University; during this war has studied the effect of explosion blast on the human body.

SIDNEY CROSS HARLAND, plant breeder.

PROF. GEORGE ARMAND ROBERT KON, research professor of chemistry at the Royal Cancer Hospital, London.

ANDREW MCCANCE, director and general manager of Messrs. Colville's, Ltd., Motherwell; D.Sc. (London) and an old boy of the Royal School of Mines.

DR. ALEXANDER LOGIE DU TOIT, lately consulting geologist to the De Beers Consolidated Mines.

ARTHUR FELIX, bacteriologist at the Lister Institute.

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